

USDA FY 2013 AVOIDING HARM FROM INVASIVE SPECIES (USDA Do No Harm 2013 Report)

A USDA Report to the Invasive Species Advisory Committee and the National Invasive Species Council by Hilda Diaz-Soltero, USDA Senior Invasive Species Coordinator

January 6, 2014

There are eight U.S. Department of Agriculture (USDA) agencies that work on invasive species issues: the Agricultural Research Service (ARS); Animal Plant Health Inspection Service (APHIS); National Institute for Food and Agriculture (NIFA) (formerly the Cooperative State Research, Education and Extension Service (CSREES)); Economic Research Service (ERS); Farm Service Agency (FSA); Foreign Agricultural Service (FAS); USDA Forest Service (FS) and Natural Resources Conservation Service (NRCS).

Previous USDA Do No Harm Reports cover: (1) fiscal year (FY) 2004 activities; (2) FY 2005 activities for ARS, APHIS, CSREES, ERS and NRCS (first report dated October 2004); (3) FY 2005 activities for the Forest Service (report dated February 2005); (4) FY 2006 activities for ARS/NAL, CSREES, ERS, NRCS and USFS (report dated March 2007); (5) FY 2006 activities for APHIS (report dated August 20, 2007); FY 2006 activities for ARS (report dated September 22, 2007); (6) FY 2007 activities for APHIS, ARS, ARS/NAL, APHIS, CSREES, ERS, FAS, FS and NRCS (report dated 20 March 2008); (7) FY 2008 activities for APHIS, ARS, ARS/NAL, APHIS, CSREES, ERS, FAS, FS and NRCS (report dated March 3, 2009); (8) FY 2009 activities for ARS, ARS/NAL, APHIS, NIFA, ERS, FS and NRCS (report dated February 17, 2010); (9) FY 2010 activities for ARS, ARS/NAL, APHIS, NIFA, ERS, USFS and NRCS (report dated 14 March 2011); (10) FY 2011 activities for ARS, ARS/NAL, APHIS, NIFA, ERS, USFS and NRCS (report dated 27 Feb 2012); and (11) FY 2012 activities by ARS, ARS/NAL, APHIS, NIFA, ERS, USFS and NRCS.

This is the twelfth “USDA Do No Harm Report” to the Invasive Species Advisory Committee and the National Invasive Species Council. It covers the FY 2013 activities for ARS, ARS/NAL,

APHIS, NIFA, ERS, USFS and NRCS. The report is dated January 6, 2014.

The report is divided by agency activities. Each agency will report on:

- a) Invasive species program activities the agency is carrying out to do no harm;
- b) The way in which, when the agency carries out other programs activities, they are also designed and implemented to do no harm;
- c) Activities that are doing harm and future actions the agency will take to change the activities so that they do no harm.

Within the above categories, the agency will include its own activities as well as activities where the agency is coordinating and/or collaborating with another federal agency, per the mandate of the Invasive Species Executive Order (EO 13112).

I. USDA Research Agencies:

A. Agricultural Research Service (ARS)

The **Agricultural Research Service (ARS)** Agricultural Research Service (ARS) is the principal in-house research agency of the USDA. With a staff of over 8,000 employees, ARS carries out research at over 100 laboratories throughout the Nation and in several foreign countries. ARS research is organized under four broad categories: Animal Production and Protection; Nutrition, Food Safety, and Quality; Crop Production and Protection; and Natural Resources and Sustainable Agricultural Systems. Pest management, including invasive species, is a major research component across all these areas. Research infrastructure dedicated to pest management includes personnel and facilities in domestic and foreign laboratories that also provide support to other agencies, organizations, and state governments. ARS is committed to performing its research programs and projects in a manner that does not cause or promote the introduction or spread of invasive species in the United States (U.S.) or elsewhere, ensuring that all feasible and prudent measures are taken to minimize risk of harm.

1. Activities that do no harm

A. Informational Activities.

e-Government and Public Communication Initiatives:

USDA's National Invasive Species Information Center (NISIC) at the National Agricultural Library (NAL) maintains and manages the www.invasivespeciesinfo.gov Web site as a reference gateway to information, organizations, and services about invasive species. The Center supports the work of the U.S. Department of Agriculture and the National Invasive Species Council in meeting the information requirements of the [Executive Order 13112](#). The Center and its Web site serve a broad customer base, from students, to farmers, researchers, and government officials.

NISIC's site pulls together extensive invasive species information in one source as a portal that does not exist elsewhere, and provides up to date federal information that supports the National Invasive Species Management Plan's Implementation Tasks.

As the resources available through NISIC continue to increase, the site maintains its reputation as authoritative portal for identification of, and access to Federal invasive species resources and activities. The www.invasivespeciesinfo.gov Web site is frequently cited in many news articles as a good source of invasive species information. NISIC's Web site consistently is ranked highly in all major search engines and is linked to many invasive species related Web sites (Federal, State, International, and non-profit organizations).

NISIC maintains a high quality online web presence and provides reference services to a wide variety of stakeholders (local, state, tribal, federal managers, scientists, policy-makers, landowners and land managers, agricultural producers, teachers, students, media journalists, and others), with very limited staff resources (1.11 FTE).

FY 2013 NISIC Statistics Summary:

Statistics data from Google Analytics (Oct 1, 2012 – Sep, 30, 2013):

- Web site statistics:
 - NISIC Site:
 - Page views - 2,638,913 (+.3 percent increase from FY 2012)
 - Visits - 1,191,598 (+5.6 percent increase)
 - Unique visitors - 939,139 (+11.6 percent increase)
 - What's New RSS Feed (separate server):
 - Page views - 7,671 (-20 percent decrease from FY 2012)
 - Visits - 5,625 (-20 percent decrease)
 - Unique visitors - 5000 (-12 percent decrease)
 - ITAP.gov (Google Analytics code was implemented 10/15/12)
 - Page views – 12,762
 - Visits – 10,530
 - Unique visitors - 10,334

Although traffic shows increased traffic over time, statistics vary due to weekends, holidays and summer months for academic users. Various configurations were changed during the year for standardization (filtering out NAL IP addresses, tracking PDF files, etc.); data may not be completely consistent and accurate for FY 13).

- Twitter Stats - [Invasiveinfo](#):
Notable followers include many various Federal, State and Non-profit organizations (including many Twitter verified official accounts).
 - Total followers – 1,984 (+52% increase from FY 2012)
 - Total lists – 137 lists (+36% increase from FY 2012)

NISIC Reference Requests:

- NISIC responded to 311 reference requests for FY 2013. Questions come from NISIC “Ask a Question” form as

well as other messages forwarded from USDA and ARS's Ask the Expert, and NAL's AgRef (Agricultural Reference) if they are related to invasive species issues.

- The types of questions NISIC received routinely range broadly from students to international researchers, general public, media, and other government agency personnel. NISIC received reference requests from a variety of patrons in FY 2013.
- Sampling of positive feedback received for NISIC reference services:
 - Research Officer, Institute of Forest Biodiversity (India); provided information for management strategies for lantana camera.
"It was very informative & useful to me. Thanks once again."
 - Freelance Science Writer (Tennessee); provided information on historical information for kudzu related to erosion control in the southeast.
"Thanks so very much for this info. At first glance, it's very helpful."
 - Ecologist (Ph.D.), National Park Service (Kentucky); in response to problem with our RSS feed
"I find your services very useful. I often send links to interested parties in our network and/or use them in the execution of my duties. Thank you for your follow up!" and previously "I really enjoy getting the "Invasive Species News" and "What's New" emails; the stories contained therein are usually interesting and informative."
 - Homeowner (California); provided funding information for removing invasive species on private property
"This is very helpful, thank you so much!!"
 - Certified Wildlife Biologist (Arkansas); provided information about acreage of non-native species of plants vs. the acreage of invasive species in the U.S.
"Your answer is greatly appreciated."
 - Staff from Grassland Trust (Southern Colorado/Northern New Mexico); provided information for a USDA, FS study regarding

invasive species on rangelands

"Thanks, Joyce. Terrific to have this. Really appreciate your effort and having this research."

- High School Student in a gifted and talented independent research program (Maryland); provided information about invasive species and the impacts upon agriculture and the related economic effects.

"Dear Ms. Bolton, Thank you so much for taking the time to reply to my request; I truly appreciate it. Also, thank you for sending me so many sources discussing invasive species. I am sure that they will be very helpful to me. Thank you again."

FY 2013 NISIC Information Products and Enhancements:

- New Content – NISIC frequently added new relevant content for many site topics including: invasive species bills, federal and state press releases, management plans, grants and funding opportunities, conferences and events, education for professionals, specific profiles resources, and much more. NISIC developed new species profiles for current species of interest, such as Burmese python, beech bark disease, chestnut blight, and others.
- Social Bookmarking – NISIC uses a social bookmarking widget on Web site pages which allows users to easily add NISIC pages to various common social bookmarking sites. This utility enables NISIC to monitor additional statistics and extend its outreach.
- RSS Feeds – NISIC provides customized RSS feeds for What's New on Our site, Invasive Species News, Invasive Species Journal (Invasive Plant Science and Management), and various Emerging Issues feeds. Hundreds of Subscribers receive NISIC's various daily email updates. Subscribers to NISIC's email updates include users from many Federal and State agencies, universities and school systems.

NISIC Hosts Unique Content:

- Extensive [Invasive Species Conference Calendar](#)

- Includes Global and all tax related conferences
 - Many sites link to NISIC's calendar, instead of creating/maintaining their own resource
- Species profiles: New profiles focused on species identified and included on USDA, Animal and Plant Health Inspection Service's (APHIS) list of top pests that threaten America's crops and forestland.
- Provided relevant invasive species information across Federal agencies (highlighting Federal press releases, USDA blog items, Federal Register notices, invasive species legislation, grants and funding, etc.).
- NISIC Site Hosted Content:
 - **USDA Reports:**
 - USDA Do No Harm Reports to the Invasive Species Advisory Committee (ISAC) and the National Invasive Species Council
 - USDA Reports to the Invasive Species Advisory Committee (ISAC)
 - **USDA Grants Workbook** (updated yearly) – U.S. Department of Agriculture Grant and Partnership Programs that Can Address Invasive Species Research, Technical Assistance, Prevention and Control
 - **2010 Microbial Biocontrol Symposium** of Arthropods, Weeds, and Plant Pathogens: Risks, Benefits and Challenges (Presentations, Presentation Summaries and Movies)
 - Various additional reports and conference proceedings not hosted elsewhere

NISIC Supports USDA/ARS and Other Federal Initiatives

- National Invasive Species Council Support:
NISIC continued to support the activities of National Invasive Species Council (NISC) by posting relevant information and as requested by Hilda Diaz-Soltero, USDA Senior Invasive Species Coordinator (conferences, federal register notices, Invasive Species Advisory Committee information, etc.), as well as additional information from the Federal Agencies that are members of the Council.

- Other e-Government and Public Communication Initiatives: [Invasivespeciesinfo.gov](http://invasivespeciesinfo.gov) Web site links: NISIC's Web site links to the 13 Federal Agencies that are members of the National Invasive Species Council, as well as links to the many Agency specific programs and resources relevant to invasive species issues. NISIC also includes extensive resources for State, Professional and Non-Profit, and International programs with an interest in the prevention, control, or eradication of invasive species.
- Information management support to ITAP: NISIC provides technical and information management support for the Federal Interagency Committee for Invasive Terrestrial Animals and Pathogens (ITAP), a Federal scientific and technical interagency advisory group. This includes:
 - Web site – www.itap.gov (developed, maintained and hosted at NAL)
 - Site was migrated to Drupal in FY 2013.
 - Supports SharePoint a secure Web-based internal communication platform.
 - Listserv for committee-wide communication.

2. Other ARS Research activities also designed to do no harm:

Invasive species information portal: USDA's National Invasive Species Information Center (NISIC) at the National Agricultural Library's Web site (invasivespeciesinfo.gov) provides an information gateway to invasive species information; covering Federal, State, local and international sources. The site pulls together extensive invasive species information in one source as a portal that does not exist elsewhere, and provides up to date federal information that supports the National Invasive Species Management Plan's Implementation Tasks.

B. ARS Research Activities

1. Activities that do no harm

Plant Diseases

Molecular diagnostic assay for wheat stem rust Ug99 strains: Strains of the wheat stem rust pathogen in the group Ug99 are threats to wheat production worldwide, and while these strains are not yet in the United States, U.S. wheat varieties are vulnerable to Ug99. Until now, the only way to distinguish Ug99 strains from other forms of wheat stem rust was to put the fungus spores on wheat plants and wait for disease to develop. ARS scientists in St. Paul, Minnesota, have developed a two stage assay based on fungal DNA to distinguish among rust strains. The first stage determines if the sample belongs to the Ug99 strain group, while the second stage predicts the specific strain. This assay is currently being used to track the movement of the Ug99 in Africa where the disease is endemic. Deployment of this assay in the United States would greatly enhance growers' ability to detect and identify any Ug99 introductions and to provide information for responding to potential outbreaks.

Causal agents discovered for maize lethal necrosis disease: In 2012, a new corn disease, maize lethal necrosis, emerged in Kenya, which caused growers to experience 40 to 100 percent crop losses. While maize lethal necrosis has not yet been found in the United States, the \$60 billion U.S. corn crop is vulnerable to this disease. ARS researchers in Wooster, Ohio, collaborated with scientists from the International Maize and Wheat Improvement Center and the Kenya Agricultural Research Institute to identify two viruses, Maize chlorotic mottle virus and Sugarcane mosaic virus, in diseased maize that together cause the maize lethal necrosis disease. This finding enables ARS scientists and collaborators to identify disease control measures and to develop screening protocols needed to breed disease-resistant corn hybrids.

Natural plant molecules disrupt nematode development: Safe strategies for managing plant parasitic nematodes should effectively control these target pests while having minimal impact upon the environment and nontarget species. Using the most economically important plant nematodes in the United

States, the soybean cyst nematode and the root knot nematode, ARS scientists in Beltsville, Maryland, found that plant chemicals called catechins inhibit nematode hatching and also significantly inhibit nematode enzymes called proteases. The catechins affect three specific proteases that are part of a complex structure central to nematode survival. Without proper protease function, nematodes fail to develop and will die. This discovery is important because it demonstrates a molecular basis for how this plant chemical can suppress plant parasitic nematode development and reproduction at low doses. In addition, it also demonstrates that catechins can be used as nematode control agents. This information will help scientists develop precision treatment strategies for controlling plant parasitic nematodes and help growers seeking to decrease synthetic chemical use in crop protection.

Flat mite identification tool on the Web: Flat mites, such as false spider mites, red palm mites, citrus mites, and peacock mites, are devastating pests on citrus, tea plants, bananas, coconuts, date palms, olive crops, eucalyptus trees, and ornamental palms. In addition to directly causing damage, these mites also vector plant diseases, including citrus leprosis virus. Accurate identification of these mites is the first step in controlling them. ARS researchers in Beltsville, Maryland, in collaboration with APHIS developed an interactive online identification key with descriptors and numerous images using light microscopy and low temperature scanning electron microscopy. Since its launch one year ago, more than 123,800 visitors from 180 countries have accessed the Web site. This tool has enabled correct identification by farmers, extension agents, State and university researchers, government agencies, and APHIS quarantine specialists in controlling mites and plant diseases vectored by mites

Causative agent of red blotch disease of grapevine: Red blotch disease causes significant vineyard losses due to reduced yields and grape quality. ARS scientists in Davis, California, discovered and characterized a new Gemini-like virus, associated with this disease, named Grapevine red blotch-associated virus (GRBaV). Epidemiology of Red Blotch disease

suggests GRBaV exhibits insect-mediated transmission. The scientists developed red blotch-specific DNA primers to detect and quantify the virus. These DNA primers are now widely used by both diagnostic testing services and grapevine virologists around the world including in the United States, Australia, Canada, France, Italy, New Zealand, and South Africa.

Robotic high-throughput extraction procedures for citrus pathogens: Rapid and standardized methods are needed for detection of citrus pathogens for certification and disease management programs, including nursery pathogen-free budwood certification that is critical to establish healthy citrus orchards. ARS researchers in Parlier, California, in collaboration with scientists at the University of California, Riverside, the University of Bari in Bari, Italy, and, Consiglio Nazionale Delle Ricerche Bari (National Research Council), adapted an automated procedure for nucleic acid extraction from citrus tissue. The scientists optimized homogenization and reagent concentrations for pathogens from citrus using a robot with magnetized beads. The samples contained enough pathogen RNA and DNA to allow reliable detection of pathogens in PCR assays. The new extraction method is being used by the California Citrus Research Board's Dimitman Laboratory for diagnosis of the pathogen associated with Huanglongbing (also known as citrus greening), as well as the University of California Citrus Clonal Protection Program in Riverside, California for citrus nursery pathogen-free budwood certification.

Method for the detection of *Triticum* mosaic virus developed: The availability of diagnostic methods for rapid, sensitive, and large-scale detection of viruses is crucial for the management of plant viral diseases. Diagnostic methods for *Triticum* mosaic virus, a recently reported virus from the Great Plains region, are not available. ARS scientists in Lincoln, Nebraska, produced polyclonal antibodies against the bacterially expressed coat protein of *Triticum* mosaic virus. In enzyme-linked immunosorbent assays (ELISA), these antibodies detected various isolates of *Triticum* mosaic virus in crude plant sap, but

not in extracts of healthy or Wheat streak mosaic virus-infected plants. The availability of *Triticum* mosaic virus antibodies would provide a high-throughput ELISA-based detection method and germplasm screening in wheat breeding programs. A biotechnology company is in the process of commercializing these antibodies for the development of a *Triticum* mosaic virus diagnostic kit.

New species of cyst nematode: Cyst nematodes are an important group of plant pathogens because they damage the roots of many kinds of crop plants worldwide and can halt trade between countries because they may be regulated by quarantine. ARS scientists in Beltsville, Maryland, and Corvallis, Oregon, in collaboration with Oregon State University, described the detailed anatomical and molecular features of a new cyst nematode, *Globodera ellingtonae*, discovered in soil samples collected during surveys to detect potato cyst nematodes. The new nematode, which was first found in Powell Butte, Oregon, shares key anatomical features with two potato cyst nematodes species of regulatory concern, the pale potato cyst nematode and the golden nematode. The newly described species can confound accurate diagnosis of potato cyst nematodes because current molecular tests are not set up to identify it. The morphological and molecular data describing this lookalike species will help scientists, regulators, and extension agencies to more accurately identify and prevent the spread of potato cyst nematodes.

Crop Production

Reducing environmental impacts of wine grape production: Better identification of the environmental impacts of wine grape production could help growers facilitate targeted improvement in production system sustainability. ARS scientists in Davis, California, have developed a tool that helps growers and policymakers understand the full environmental impacts of an agricultural production system and identify ways to improve overall efficiency. The Life Cycle Assessment (LCA) tool has been used to assess environmental impacts of wine grape production across a range of vineyard management regimes in

two important growing regions of California. The tool evaluates resource extraction; manufacturing of raw materials into products used in wine grape production (e.g., herbicide and fertilizer) and their subsequent transport to the vineyard; activities and energy required to grow the wine grapes (e.g., irrigation and harvest); and final transport of wine grapes to the winery. The tool helped scientists discover a number of alternative management practices, including but not limited to compost, reduced irrigation, and various cover cropping systems that will assist growers seeking to improve the energy use and air emissions of their vineyards.

Attractants for brown marmorated stink bug: The brown marmorated stink bug (BMSB) is an invasive insect pest that causes severe damage to fruits, vegetables, and field crops that has spread to 40 states, as well as to Canada, Switzerland, Germany, and France. A means of monitoring the numbers of stink bugs is necessary for determining when to apply treatments. ARS scientists in Beltsville, Maryland, have confirmed that the bug is attracted to methyl decatrienoate (MDT), a pheromone of a different Asian stink bug species. The researchers have developed and commercialized a new synthesis of this compound for use in monitoring traps. In addition, ARS scientists in Kearneysville, West Virginia, and Beltsville, discovered the true male produced aggregation pheromone of the stink bug and confirmed in field trials that it is attractive to male and female adults and immature bugs. The pheromone was developed into a commercial version that has been transferred to the private sector. ARS scientists in Beltsville also discovered that the performance of the bug's pheromone could be enhanced (synergized) by MDT, providing a superior lure for season-long monitoring. A patent application has been filed on discovery of the brown marmorated stink bug attractants. It is expected that the commercialization of this pheromone technology will lead to effective management of the pest and new trap-and-kill techniques to reduce pesticide usage. ARS provided pheromone lures to collaborators and Extension personnel in 20 states to assist in monitoring and detection efforts for BSMB presence and activity.

Drift reduction protocol for aerial and ground spray applications: With numerous new spray technologies and methods being developed for drift reduction, standardized measurement and evaluation methods are needed to advise applicators on the degree of drift reduction. ARS researchers in College Station, Texas, working closely with the U.S. Environmental Protection Agency and other research and manufacturing entities, evaluated and refined application protocols and techniques, and developed a generic testing protocol that provides objective and unbiased testing of various drift reduction techniques. The protocol, entitled "U.S. EPA Generic Verification Protocol for Testing Pesticide Application Spray Drift Reduction Technologies for Row and Field Crops," was released by the EPA Office of Pesticide Programs in mid-2013. The document is a critical regulatory resource to assure minimization of drift in agricultural spray applications.

Varroa mite migration represents a new control challenge: Varroa mites are a major cause of colony losses in honey bees because they parasitize bees and spread viruses in the colony. ARS researchers in Tucson, Arizona, devised a treatment schedule to control Varroa based on colony and Varroa population dynamics. The researchers found that Varroa populations could be kept at low levels throughout most of the summer with this treatment schedule. However, by fall, mite populations were much larger than predicted or than could be accounted for by mite reproduction alone. The researchers determined that mites appear to be migratory and move between colonies with far greater frequency than previously thought. This finding led to changes in recommendations on Varroa control that include a late fall treatment so mite populations remain low over the winter to prevent the loss of colonies in the spring.

High fructose corn syrup and honey bee colony health: When flowering plants are unavailable, beekeepers feed colonies high fructose corn syrup to supplement their diets. ARS researchers in Tucson, Arizona, found significantly larger adult bee populations in colonies fed sucrose syrup compared with those fed high fructose corn syrup. This finding complements earlier

studies showing shorter life spans in worker bees fed high fructose corn syrup compared with sucrose. This information allows commercial beekeepers to select better diets for their bee colonies to leave them less vulnerable to loss from environmental fluctuations, parasites, and pathogens.

Use of biochar as a component in greenhouse substrates:

Fertilizers are becoming increasingly expensive due to the energy required to manufacture them or the cost of mining the raw materials. Phosphorus and potassium are two of the primary nutrients used in fertilizers. ARS scientists in Wooster, Ohio, determined that gasified rice hull biochar, a commercially abundant byproduct from the processing of rice, contains a high concentration of phosphorus and potassium, and has potential as an alternative source for use in commercial potting substrates for greenhouse and nursery crops. The scientists determined that the optimal rate for amendment with gasified rice hull biochar into a typical greenhouse potting substrate is 10 percent by volume. At this rate, sufficient phosphorus and potassium are provided for a variety of crop species without additional nutrients being provided. This data provides the industry with baseline information on rates of application that can be used when this product becomes available to the horticultural industry.

Excessive iron triggers nickel deficiency: Nickel deficiency not only influences alternate bearing by pecan trees, but also reduces yield and quality of many other crops. Factors affecting the cellular bioavailability of nickel in plants have the potential to influence the health, yield, and quality of plant products. ARS researchers in Byron, Georgia, determined that nickel deficiency is easily induced by excessive iron fertilization or plant exposure to iron. The scientists noted that the iron acts in an antagonistic manner to nickel bioavailability and nutritional physiology. This research identifies an important micro-nutrient interaction in plants that has heretofore been unrecognized and has the potential for practical applications in agriculture. For example, the research identified iron fertilization as a means of alleviating nickel toxicity in crops, especially those growing on highly mineralized serpentine soils. The findings also highlight

the possible existence of iron-induced nickel deficiency occurring in many cropping systems where iron is a fertilizer supplement.

Crop Protection & Quarantine

Discovery, field release, and establishment of new natural enemies of Giant Reed in Texas: Giant Reed (*Arundo donax*) is a highly invasive weedy grass from the Mediterranean region that displaces native riparian vegetation in the United States and clogs waterways along the Southern border. Its dense thickets also hinder effective border patrol activities and provide habitat for the tick that carries cattle fever. Giant Reed became a problem in the United States because it lacks effective natural enemies. Scientists at ARS' European Biological Control Laboratory in Montpellier, France, have now identified four candidate natural enemies after making more than 250 field collections in Spain, France, Italy, and Greece. The candidates were shipped to U.S. quarantine facilities in Mission, Texas, where ARS scientists evaluated them for safety and efficacy against the weed. Two of the agents, a gall forming wasp (*Tetramesa romana*) and a scale insect (*Rhizaspidiotus donacis*), have received APHIS permits and have been released into the field. A third agent, a leaf mining fly (*Lasioptera donacis*), is currently being evaluated in quarantine. During the past year, ARS scientists in Kerrville, Texas, and in Montpellier, France, have also made significant advances in understanding the biological association of the defoliating leafminer fly and associated endophytic pathogens. The fly has previously undiscovered specialized organs on its ovipositor in which it stores the spores of a single species of fungus. The fungus appears to be necessary for complete development of the fly and is probably responsible for much of the damage to the *Arundo* plant. As these natural controls spread they will help to suppress the grass and restore original riparian habitats.

Insect control for export of table grapes and sweet cherries: Spotted wing drosophila (*Drosophila suzukii*) is a newly found invasive pest in the western United States that threatens the ability of growers to export California grown table grapes and

sweet cherries which have an annual export value estimated at \$200 million to Australia and New Zealand. ARS scientists in Parlier, California, developed a combination of sulfur dioxide fumigation and cold treatment as a postharvest alternative to methyl bromide fumigation for controlling this pest in California grown table grapes. The scientists further enhanced producer's ability to export grapes by developing a method to remove fungicide residues using ozone fumigation. Following requests of the western U.S. cherry industry, the scientists also completed the validation of a quarantine treatment utilizing methyl bromide fumigation. This research has enabled the retention and expansion of market access to Australia, estimated at \$55 million annually.

Systems for gene targeting and producing stable insect transgene insertions: Genetically transformed insect strains can improve sterile insect technique (SIT) programs and elucidate new genomic targets for insect control. However, current methods do not allow transgene DNA insertions to be targeted to known genomic locations, resulting in unreliable transgene expression and insertional mutations that negatively affect host strain fitness. Transposon-based vectors also may be remobilized resulting in strain instability. To remedy this, ARS scientists in Gainesville, Florida, developed new gene targeting systems based on recombinase-mediated cassette exchange (RMCE) that can avoid genomic insertion sites subject to mutations and suppression of gene expression, and which allows post-integration stabilization of the vector, thus preventing its potential loss or transfer to non-target species. These methods will improve SIT by providing highly effective male-only transgenic strains that are genetically sterile, saving mass rearing costs, avoiding debilitating effects of male irradiation, and providing enhanced environmental safety. These techniques might also enable strategies that drive genes into insect populations to eliminate negative traits of pests, such as their ability to vector diseases.

Culture collection a globally essential resource for research on fungi from invertebrates: Some fungi kill insects and are excellent biocontrol agents or biopesticides. To assure their

insect host-specificity, they must be characterized, which poses a major challenge because of their hidden life stages, subtle differences in species, and ability to hybridize widely. The ARS Collection of Entomopathogenic Fungal Cultures in Ithaca, New York, continues to be the pre-eminent American resource of fungal germplasm originating from insects, mites, ticks, and other invertebrates. With recent addition of 3,200 isolates, the collection now includes nearly 12,000 isolates of some 700 fungal taxa that were collected from 1,300 host arthropods from around the world. This year, scientists reclassified the class Entomophthorales to the phylum Entomophthoromycota. This group includes the pathogen that has brought gypsy moth under natural control for the first time in over a century. A better understanding of this group will facilitate exploration for fungi to control other arthropod pests.

First molecular phylogeny of the family Tortricidae (leaf-roller moths): Phylogenies provide working hypotheses of genealogical relationships among organisms that can be used to develop more robust and meaningful classifications and potentially predict behavior, host utilization, and invasiveness of plant-feeding insects. ARS scientists, working with international collaborators, developed the first molecular phylogeny for the leaf-roller moth family, Tortricidae. This family includes numerous pests of crops, ornamentals, and forests worldwide. The phylogeny is based on a model that attempts to group species according to common evolutionary ancestors. The practical implications of such a phylogeny can be that evolutionarily related species share characteristics of concern to agriculture. The scientists showed that species depositing small batches of eggs usually feed inside fruits; whereas, species laying large clusters of eggs tend to feed externally on a wide variety of plants. The internal feeders are more difficult for inspectors to detect in commodities shipped to the United States. The phylogeny gives inspectors the tool necessary to predict what species are likely to be feeding internally, therefore justifying more intense inspection. These findings provide a broad-scale framework for predicting which tortricid species are most likely to cause significant economic damage to fruit and

seed crops and which species may elude detection at ports of entry.

New biocompatible foams deliver living microbial agents for insect pest control: Many pest insects hide in locations that cannot be reached with conventional insecticide sprays. Pest control operators commonly use foam spraying technologies to deliver insecticides to these difficult-to-reach insect habitats. Unfortunately, the chemicals typically used in pesticide foams are detrimental to most microbial biological control agents, and cannot be used in organic farming operations due to the nature of their chemical composition. ARS researchers in Peoria, Illinois, developed and patented a natural, protein-based foaming agent technology compatible with living microbial agents and safe for use in organic pest control. This technology has been successfully used to treat a number of insect pests, including several moth and beetle pests of fruit trees, as well as Formosan subterranean termites. Although natural termiticidal microbial agents have been identified, their effectiveness has been limited by how and where they can be applied due to the termites' subterranean nature. The foam technology developed by the Peoria team overcomes those problems and provides a mechanism for expanded use of microbial control for termite control, organic crop systems, and other uses.

Ambrosia beetle model: The exotic ambrosia beetle (*Xylosandrus germanus*) is one of the most problematic ambrosia beetles in ornamental nurseries in the Northeastern, Midwestern, Atlantic, and Southeastern states. Because these beetles are so small and difficult to detect, it is difficult for growers to synchronize their protective sprays with beetle activity. Sprays applied too early are wasted, while excessive damage can occur when sprays are applied too late. ARS scientists in Wooster, Ohio, developed a model for predicting emergence of the ambrosia beetle based on the bloom sequence of ornamental plants, and a model based on daily maximum temperatures wherein an extended weather forecast can be used to predict beetle activity. This model can be used by growers to determine whether they need to spray or can

wait, enabling growers to be more efficient controlling ambrosia beetles and to save money by not applying unnecessary insecticide sprays.

Fighting the ambrosia beetle that transmits laurel wilt: Redbay ambrosia beetle (*Xyleborus glabratus*) is a small wood-boring beetle that probably invaded the U.S. on untreated wooden packing material. The beetle was originally from Asia and transmits a pathogen responsible for laurel wilt, a fatal condition for many species of trees in the laurel family, including California bay, sassafras, redbay, Asian spice bush and avocado. An effective lure is needed to provide a reliable means to determine whether or not areas were infested, as well as a possible component of attract-and-kill products. ARS scientists in Miami, Florida, documented that the current redbay ambrosia beetle lure, manuka oil, lasts only 2 to 3 weeks due to evaporation of its principle active chemical, alpha-copaene. Using a combination of analytical chemistry, collection of beetles in the field, and direct measurement of the neural olfactory response in the beetles' antennae, the scientists identified seven essential oils as possible sources of effective attractants. The best was a cubeb, a distillate from berries of *Piper cubeba*. This product is being commercialized with the help of an industrial partner. Research is ongoing to determine if the attractant could lead to an efficient product for killing the beetle, as well as for identifying and controlling infestations.

Wheat field image analyses identify Russian wheat aphid infestations: Multispectral remote sensing has not been widely adopted in agricultural pest management because of the technology's inability to distinguish among the various factors, such as drought, pest insects, diseases, and nutrient deficiencies. A new methodology developed by ARS scientists in Stillwater, Oklahoma, in collaboration with university colleagues, overcomes this limitation and now assists growers in making management recommendations at field, sub-field, and multi-field scales, at a much lower cost than traditional pest scouting and sampling methods. The methodology combines field-scale multispectral imagery acquired from an airborne platform with spatial pattern recognition algorithms to

differentiate wheat fields infested by Russian wheat aphids from non-infested fields. The system is cost effective because large spatial areas can be imaged rapidly at 25 cents per acre. Validation showed the methodology to be more than 95 percent accurate at differentiating infested from non-infested fields. Growers can now use this method to assign relative pest risk to manage fields and target field-level activities accordingly.

Veterinary, Medical and Urban Entomology

DEET mosquito repellent works by taste as well as by smell:
Current mosquito repellents are effective if used correctly, but dosages applied to the skin are very high. Prevention of disease transmission using repellents is a problem because people are reluctant to use unpleasant products until they have already been bitten. Ideally, a repellent active ingredient would be developed that functions at the kinds of concentrations usually observed in the pharmaceutical industry – approximately 1000 times more effective than DEET. ARS scientists at Beltsville, Maryland, have been working to understand the physiological mode of action of repellents. Unexpectedly, they found that DEET not only affects odor receptors on the antennae, but also taste receptors on the mouthparts. The new understanding that taste and odor are involved in the function of this effective repellent opens the door to more precisely targeted exploration for repellent active ingredients that work at much lower concentrations. This discovery will change the way that new repellent active ingredients are evaluated and ultimately produce highly effective products that have a greater chance of preventing infection than current repellents.

Gene silencing technology leads toward safe mosquito control:
There are a very limited number of public health pesticides available for controlling medically important vectors, such as mosquitoes and sand flies. This novel approach is based on the technology that allows for the specific silencing of genes critical to survival of the target vector species. This technology uses double stranded RNA (dsRNA) and the process of RNA interference (RNAi) to prevent the synthesis of specific proteins

in cells. By choosing the right target, it is possible to debilitate mosquito vectors of disease. ARS researchers in Gainesville, Florida have demonstrated that a dsRNA construct targeting a gut-expressed gene effectively shut down production of that protein when fed to the adult yellow fever mosquito. The dsRNA was fed to the mosquitoes in a sugar meal and stopped the protein in 12 or 24 hours. Oral delivery of dsRNA to mosquitoes could be a very practical way to deliver this new technology. The specificity of the dsRNA would prevent any danger to other insects, including pollinators. Also, only tiny quantities of dsRNA would be required, reducing costs. This work will lead to products that have no non-target effects and that are perfectly safe for humans and the environment.

How house-fly maggots live in bacteria-rich media: House flies breed in environments such as garbage and manure, exposed to numerous species of bacteria. Many of those bacteria are human or animal pathogens. Remarkably, the house –fly maggots are seldom harmed by the soup of bacteria in which they live. The interaction of the fly maggot's own immune system and the bacteria in its medium is important in determining whether or not the adult flies emerging from the maggots will carry pathogenic bacteria. In collaboration with Clemson University, ARS scientists in Manhattan, Kansas sequenced genes that were activated in immune-stimulated house flies, and identified several sequences that coded for molecules that protect the maggots from bacteria. Production of these substances creates a component of the maggots' immune system, allowing it to live in contaminated environments and determining which pathogens survive in the adult fly. The protective genes induced by immune challenge have been made public. An understanding of the intricacies of the relationship between larval flies and bacteria will lead toward better ways of protecting food and livestock from pathogens.

Viruses as powerful new way to control fire ants: Fire ants have become a problem in the United States and Asia because they do not have the complex of natural enemies that keeps them in check in their native South America. ARS researchers

at Gainesville, Florida, have worked with the Foundation for the Study of Invasive Species, Hurlingham, Argentina, for years to find and import small flies that parasitize fire ants. Those efforts have resulted in an approximately 30 percent reduction of fire ants in the southeastern United States. More recently, the two laboratories discovered the first viruses in any ant, one of which is particularly deadly for fire ants. This virus can be administered in bait and then sustains itself in a population through natural transmission. Adaptation of this product to area-wide programs will further reduce fire ant populations in the United States and lessen the impact of their range expansion associated with climate change.

Sequencing the genome of the cattle fever tick: Two species of cattle fever ticks that transmit babesiosis were responsible for the death and poor yield of cattle throughout the southern United States. They remain an important problem throughout the tropics. Beginning in 1912, a systematic program of dipping cattle and quarantining pastures totally eradicated the tick from the United States. The ticks are kept out of the United States through border inspection, inspection and treatment on farms in South Texas, and interception of infested cattle that wander across the border. The current acaricide used in the program is one of the few remaining organophosphates still on the market. Alternatives exist, but in Mexico there is resistance to any one of them. ARS scientists at Kerrville, Texas, in collaboration with researchers at Murdoch University, Perth, Australia, and the National Center for Genome Resources, have sequenced the genome of the cattle tick. Data from the genome sequence has resulted in the identification of anti-tick vaccine candidates that should provide an effective tool for the supplementation of acaricides. The sequence will also be valuable for rapid development of new acaricides targeted at new physiological processes. This is expected to accelerate acaricide research and development within USDA and the global animal health industry.

Biting midge gene expression: Biting midges are important vectors of livestock diseases, including some that have recently emerged. The northward extension of bluetongue virus in

Europe and the appearance of Schmallenberg virus suggest that changing conditions may be increasing the importance of biting midges as vectors of animal diseases. In addition, biting midges transmit epizootic hemorrhagic disease, a deadly syndrome that threatens the deer-farming industry in much of the United States. Because of the difficulty of working with these small insects, relatively little research has been done on them compared to more prominent biting insects like mosquitoes. ARS scientists in Manhattan, Kansas, in collaboration with Clemson University Genomics Institute, have worked to observe the genetic mechanisms of biting midges responsible for key biological processes. Looking at gene expression, they have discovered genes involved in blood feeding, defense, digestion, transport of materials within the insect, development, and reproduction. Pinpointing the role genes play in the life of the midge will contribute toward faster, more accurate assessment of vectorial competence and may lead to completely new modes of action for insecticides.

Chromosomal origin of fire ant social forms revealed:

Introduced fire ants exhibit two colony social forms that differ in the number of reproductive queens per colony, as well as many other traits. Remarkably, many individual and life-history traits associated with social organization are controlled by a single gene, Gp-9. ARS researchers at Gainesville, Florida, found that Gp-9 is embedded in a group of genes that are resistant to reassortment and that therefore tend to stay attached to each other (i.e., a supergene). The pair of supergenes that make up the two alleles of an individual are located on separate, dissimilar chromosomes. Most genes associated with social forms of the ants are located on these two chromosomes, which are similar to sex chromosomes in structure. These findings highlight how genomic rearrangements can maintain divergent adaptive social phenotypes involving many genes acting in concert by locally limiting recombination. This understanding of basic gene mechanics has great scientific interest and may also lead to better ways to alter the social forms of these invasive ants.

A viral biopesticide against house flies: ARS researchers at Gainesville, Florida have attempted for years to infect flies with salivary gland hypertrophy virus (SGHV) with baits. Even though flies fed on virus-laden food, they failed to be infected. The scientists unexpectedly found that surface contamination may be a more common route of infection, and that even small amounts of cuticular damage to the fly can provide routes of infection without ingesting the virus. A mathematical model of virus epizootiology was developed that suggested that the aggressiveness of male flies during courtship could provide an additional avenue of infection. These findings support the idea that a residual spray of the virus could find its way into house flies, providing a new and safe way to control these insects.

Development of a new, selective insecticide: One of the objections to pesticides is their toxicity to organisms, including humans, not intended as their targets. Although residue limits based on toxicological data protect people, compliance with those limits can be a problem. From an environmental perspective, toxic effects on any vertebrate species would be considered undesirable. ARS scientists at Kerrville, Texas collaborated with researchers at the University of Florida and Virginia Tech to evaluate a synthetic carbamate insecticide, designated PRC-408, for the control of horn, stable, and sand flies. PRC-408 was as toxic to these insects as carbaryl, an efficacious, commercially available compound. An *in vitro* assay was used to demonstrate that PRC-408 exhibited approximately 300-fold higher specificity for its arthropod target compared to its mammalian, i.e., bovine and human, target and offers improved safety compared to other chemicals in its class. This work will result in new insecticides that are very safe to use, but flexible in their application.

Desert treatments of biting insects: ARS researchers at Gainesville, Florida and their collaborators have recognized the insect control problem faced by the U.S. military and others who live in hot, dry deserts. The hot desert floor tends to disperse insecticidal fogs through convection, dispersing any insecticidal fog applied. Trials in California's Coachella Valley showed that mosquitoes in cages were killed despite the

unfavorable conditions. They also showed that droplets of the insecticide, permethrin, deposited adequately on surfaces. The results indicate that despite unfavorable conditions for traditional aerial ULV application, aerial application of insecticidal fogs against medically important mosquitoes can substantially reduce mosquito-human contact and minimize transmission of mosquito-borne viruses to military troops deployed in desert areas.

Rift Valley fever is more complicated than we thought: Rift Valley fever is caused by a virus that can be transmitted by mosquitoes or by direct contact. It can be a serious disease for people and animals, occurring in outbreaks at irregular intervals in Africa. About ten years ago it appeared outside of Africa for the first time, which raised alarm that the virus might be able to cause disease elsewhere. ARS scientists in Gainesville, Florida worked with the Kenyan researchers to examine blood sera of many animals sampled during a Rift Valley fever outbreak. They found that prevalence of positive antibodies in domestic and wild animals occurred at the places and times predicted by a model developed jointly by ARS and NASA. Studies in Africa showed unexpected transmission by *Mansonia* mosquitoes. In the laboratory, *Psorophora* and *Coquillettidia* were also shown to be competent vectors of the virus. Since some of these species live in the United States, it appears that Rift Valley fever could become endemic in the United States, as happened with West Nile virus. The consequences of the establishment of Rift Valley fever in the United States would be far more serious than for West Nile, because of Rift Valley fever's devastating effects on livestock and as a cause of serious human disease. This research gives veterinary and human health a more accurate risk assessment of Rift Valley fever.

Plant Genetic Resources, Genomics and Genetic Improvement

"Sunpreme" raisins dry themselves: Eliminating the processing step of tray drying in the field would help maintain the quality of raisins and reduce the need for costly additional post-harvest processing. ARS researchers in Parlier, California, have developed Sunpreme, a new raisin grape that dries naturally on

the vine without the grapes requiring cutting and drying in trays. Sunprime, is particularly well suited for mechanical harvesting, thereby significantly reducing production costs. Unlike Thompson Seedless, the major grape variety used for tray dried raisin production, Sunprime, can be spur-pruned, further reducing grower costs.

New citrus cryopreservation method developed: The current and future productivity and profitability of the multi-billion dollar U.S. citrus industry is threatened by virulent pests and diseases, such as citrus greening and citrus canker. These pests and diseases also threaten ARS' citrus breeding stock and genebank collections maintained in field and screen house plantings. Until now, preserving vegetatively propagated citrus germplasm under ultra-cold (cryopreservation) genebank conditions has not been feasible. ARS researchers in Ft. Collins, Colorado, and Riverside, California, developed a novel micrografting technique that results in high survival rates of citrus germplasm maintained by cryopreservation. Furthermore, the new cryopreservation technique eliminates several graft transmissible viruses and viroids. This new cryopreservation technique not only provides an effective means for safeguarding invaluable citrus germplasm, but it can also serve as a new pathogen elimination method for producing disease free citrus propagating material.

Discovery of genes for drought tolerance in the common bean: Drought strongly reduces the yields of dry beans in the Northern Plains (North Dakota and Minnesota), Great Lakes (Michigan), and other regions which rely primarily on rainfall for crop growth. Consequently, dry beans with tolerance to drought are critical for those regions, and for adapting this globally important crop to climate change. ARS researchers in Prosser, Washington, and their university colleagues identified two major genes (also known as quantitative trait loci or QTL) that strongly govern drought tolerance in dry beans. The two genes showed positive effects when the dry beans were cultivated in multiple drought stress environments. This research will enhance our capacity for marker assisted breeding to accelerate development of drought tolerant beans

by seed companies and public sector breeders in the United States and worldwide.

40,000 new genetic markers for evaluating the diversity in the USDA soybean germplasm collection: New genetic tools are needed to accelerate the pace of mining germplasm collections for valuable genes for breeding and research. ARS researchers in Beltsville, Maryland, mapped more than 40,000 single nucleotide polymorphism (SNP) DNA markers to specific chromosomal locations on the soybean genome to facilitate identifying genes that control traits of interest. These extensive data were deposited in SoyBase, the ARS soybean genome database, which is consulted heavily by public and private-sector researchers worldwide. The researchers applied the suite of 40,000 SNP DNA markers to analyze the 18,000 soybean samples in the ARS germplasm collection to identify an optimal core subset that would increase the effectiveness of genebank management. In doing so, they identified more than 4,300 samples that were 99.9 percent genetically identical and could be omitted. With the remaining samples, a core subset of about 1,400 samples was chosen that represented 79 percent of the total genetic diversity of the entire collection. This core subset enables soybean breeders and geneticists to search for key traits from a relatively small and manageable number of samples representing most of the genetic variability of the entire collection.

Rich native U. S. sources of plant genetic diversity identified for crop improvement and research: The wild relatives of domesticated crops contain rich sources of genetic diversity which new genomics assisted breeding techniques can now exploit more effectively for crop improvement. It has long been assumed that U.S. flora contains relatively few crop wild relatives. ARS scientists in Prosser, Washington, and Beltsville, Maryland, with international research collaborators, completed an inventory of U.S. flora that contains a rich trove (more than 4,600 different types) of crop wild relatives and wild species that could be exploited directly for food, forage, medicinal, ornamental, and industrial applications. This

research has furnished a blueprint for urgent action to conserve the most endangered U.S. crop wild relatives.

Novel multi-seeded mutants identified that might substantially increase sorghum grain yield: ARS researchers in Lubbock, Texas, have identified novel sorghum mutants that might significantly increase sorghum grain yield. The multi-seeded mutants have more and larger primary and secondary flower branches bearing more types of floral organs that develop into seeds. Compared to current sorghum cultivars, these mutants have tripled the number of seeds and double the seed weight. The mutants are being evaluated in the field for their ability to substantially increase sorghum grain yield.

Genes can move among the separate genomes of flowering plant cells: Genes consist of DNA, most of which is located in the chromosomes of the nuclear genome of all organisms. But in plants, small quantities of DNA are also found in the genomes of two sub-cellular compartments, mitochondria and plastids. ARS researchers in Madison, Wisconsin, and university colleagues found that DNA originally from the carrot mitochondrial genome has moved into the carrot plastid genome—the first report of DNA transfer between those genomes for any organism. These findings advance the scientific understanding of how DNA can move between separate flowering plant genomes and the possible origins of some genetic variation found both within and among different plant species.

Creating new sources of soybean genes that retard cyst nematode development: Soybean cyst nematodes attack the roots of soybean plants, causing approximately \$1 to 2 billion in damage each year. These nematodes evolve into new genetic races rapidly, especially when challenged with resistant soybeans. Very few new unique sources of resistance have been found in soybean germplasm collections. To improve soybean resistance to the soybean cyst nematode and generate new genetic diversity for breeding, ARS researchers in Beltsville, Maryland, identified approximately 50 Arabidopsis, soybean, and nematode genes as candidates for developing

partial resistance against the nematode and root-knot nematode. DNA constructs derived from these genes were incorporated (transformed) into soybean roots and challenged with either soybean cyst nematodes or root-knot nematodes. Four DNA constructs decreased the number of cysts formed by the soybean cyst nematode by 50 percent or more and decreased the number of galls formed by root-knot nematode 60 percent or more. These DNA constructs are very valuable tools for understanding mechanisms of plant resistance to these nematodes, and for developing genetically broad resistance against nematodes.

Wheat gene Mds-1 governs susceptibility to Hessian fly: Hessian fly stunts and kills wheat seedlings and causes adult plants to fall over, or lodge. Wheat resistance genes against Hessian fly are rapidly overcome by new genetic biotypes of the Hessian fly, so new strategies are needed to combat this pest. ARS researchers in Manhattan, Kansas, and their Kansas State University colleagues found a wheat gene, Mds-1, that confers susceptibility to Hessian fly. When this gene was deactivated experimentally, wheat plants became immune to all biotypes of Hessian fly. Thus, modification of susceptibility genes such as Mds-1 may confer to wheat a potentially broad and durable resistance to Hessian fly and other insects.

'Flavorfest' strawberry cultivar released: Mid-Atlantic strawberry growers face an increasing problem from plant loss and fruit-rot from the current leading strawberry variety because of its susceptibility to the fungal disease, anthracnose. ARS scientists in Beltsville, Maryland, have released the Flavorfest strawberry that is resistant to plant and fruit-rot anthracnose, has a similar season to the current leading variety, and delivers up to a two-fold higher yield of large berries with excellent flavor and creamy texture. Mid-Atlantic strawberry crop consultants and extension agents are advising growers to try Flavorfest and consider it a replacement for the current leading variety.

Massive numbers of genetic markers developed for breeding and broadening the genetic diversity of U. S. corn: Maize (corn) is the most valuable crop in the United States with a

current annual farmgate value of more than \$75 billion. But the genetic base of the U. S. maize crop is very narrow, making it potentially vulnerable to emerging diseases, pests, and environmental extremes. New methods are required to identify and conserve maize diversity, expand the crop's genetic base, and contribute valuable new traits to the U. S. maize crop. ARS researchers in Ames, Iowa; Columbia, Missouri; Ithaca, New York; and Raleigh, North Carolina, and their university collaborators developed more than 500,000 single nucleotide polymorphism (SNP) genetic markers via next-generation sequencing methods and genotyped 2,700 inbred lines, nearly all of such samples in the U. S. National Plant Germplasm System maize collection. This vast trove of genetic data helped identify misclassified samples, elucidate the genetic relationships among poorly known lines, and, combined with agronomic descriptions of those lines, identify genes that govern key maize traits. This information will be key to accelerating maize breeding that effectively incorporates valuable new genetic diversity into the U. S. maize crop.

'Mesa', first Russian wheat aphid-resistant winter feed barley variety released: Russian wheat aphid, an invasive pest of small grains, is a major problem for small grain production, requiring repeated applications of the most environmentally detrimental pesticides as a control measure. ARS researchers in Stillwater, Oklahoma, developed a new barley variety, 'Mesa,' with high levels of inherent resistance to both the U.S. types of Russian wheat aphid and those found in other parts of the world. With continued soil erosion in the western United States and new demands for a feed alternative to corn, Russian wheat aphid-resistant barley represents an advantageous environmental and economic crop option for High Plains growers.

2. Other ARS Research activities also designed to do no harm

Invasive species information portal: USDA's National Invasive Species Information Center (NISIC) at the National Agricultural Library's Web site (invasivespeciesinfo.gov) provides an information gateway to invasive species information; covering

Federal, State, local and international sources. The site pulls together extensive invasive species information in one source as a portal that does not exist elsewhere, and provides up to date federal information that supports the National Invasive Species Management Plan's Implementation Tasks.

Information management support to ITAP: USDA's National Invasive Species Information Center (NISIC) at the National Agricultural Library provides technical and information management support for ITAP, the Federal Interagency Committee for Invasive Terrestrial Animals and Pathogens (itap.gov), a Federal scientific and technical interagency advisory group.

Overseas laboratories/quarantine facilities: Classical biological control is the use of natural enemies derived from a pest's point of origin. It offers the possibility for permanent, cost effective suppression of weeds and insect pests. The ARS Overseas Biological Control Laboratories (OBCL) are located in Australia, China, Argentina, and France and work as a cohesive network. Their collective mission is to identify, develop and ship natural enemies to stateside collaborators for use in U.S. programs designed to combat invasive species. Accordingly, they represent the beginning of a pipeline of effective biological control agents and numerous stateside programs rely upon them. The ARS OBCL has a rich history of success in this regard, having contributed numerous biological control agents now in use across the U.S. ARS OBCL maintains formal collaborations with APHIS, the U.S. Forest Service, the U.S. Fish and Wildlife Service, the Bureau of Land Management, the Bureau of Indian Affairs, and many State Departments of Agriculture.

Related to this overseas work, ARS maintains quarantine facilities for insects and pathogens that meet Federal safety specifications to preclude pest introduction into the U.S. When beneficial insects arrive from overseas, they are carefully sorted, screened for parasites and reared or cultured within the quarantine facilities. ARS operates laboratories with quarantine facilities in Albany, California, Florida, Maryland, Mississippi,

and Montana. Each quarantine facility uses a variety of traps, doors, entryways and sanitizing procedures to keep the pests secure until they are proven safe for release into the U.S.

APHIS Technical Advisory Group for Biological Control Agents of Weeds: ARS is represented on the APHIS Technical Advisory Group for Biological Control Agents of Weeds (TAG). The purpose of TAG is to facilitate biological control of weeds in North America by providing guidance to researchers and recommendations to regulating agencies for or against the release of non-indigenous biological control agents. This is based on considerations of potential non-target impacts, conflicts of interest, natural resources, agricultural production, and the Endangered Species Act (ESA) Threatened and Endangered Species List.

FICMNEW: ARS is also a member of the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW). FICMNEW has representatives from 16 federal agencies with direct invasive plant management and regulatory responsibilities spanning across the U.S. and territories. FICMNEW members interact on important national and regional invasive plant issues and share information with various public and private organizations participating with the federal sector to address invasive plant issues. It develops and shares scientific and technical information, fosters collaborative efforts among federal agencies, provides recommendations for national and regional level management of invasive plants, and sponsors technical/educational conferences and workshops concerning invasive plants. FICMNEW continues to bridge the gap between federal agency invasive plant management and science activities and has been a driving force behind the national emphasis against the broader invasive species threat.

NAPPO: ARS is a participant on the North American Plant Protection Organization (NAPPO) Biological Control Committee that addresses the movement and regulation of biological control organisms used in either augmentation or classical biocontrol agents intended for release into the environment with expected establishment and pest control.

3. Activities that are doing harm, and future agency actions to change them so that they do not continue to do harm

None. As the principal in-house research agency for the United States Department of Agriculture, ARS conducts research to develop and transfer solutions to agricultural problems of high national priority. ARS scientific studies provide data and develop tools that enable America to change potentially harmful actions into those that do no harm while still meeting the challenge posed by invasive species.

B. National Institute of Food and Agriculture (NIFA) (previously named the Cooperative State Research, Education and Extension Service- CSREES)

1. Activities to do no harm

Technical Advisory Group for the Biological Control of Weeds: NIFA is a member of the Technical Advisory Group (TAG) for the Biological Control of Weeds. This advisory group is made up of representatives from various Federal agencies that evaluate candidate biological control agents for their economic, environmental, and ecological safety. Should the candidate biocontrol agents receive approval for release against a given target weed, this helps ensure that harmful non-target effects from the natural enemies are minimized. TAG advises APHIS.

National Animal and Plant Diagnostic Laboratory Networks: The safety of U.S. plant and animal production systems depends on our ability to rapidly identify foreign pathogens and other pests, whether introduced intentionally (through bio-terrorism) or unintentionally. NIFA has established two national networks of existing diagnostic laboratories to rapidly and accurately detect and report pathogens of national interest and to provide timely information and training to state university diagnostic laboratories.

The National Plant Diagnostic Network is led by five regional laboratories (Cornell University, University of Florida, Michigan State University, Kansas State University, and University of California-Davis) and one support laboratory (at Texas Tech. University).

The National Animal Health Laboratory Network (NAHLN) is led by 12 Core Laboratories and 58 total laboratories (receiving training/reagent/exercise support and being linked) in 43 states. NIFA is currently helping labs (other than the 12 core laboratories) with funding to set up electronic (secure, standards-based) messaging regarding FAD findings. These facilities will help to link growers, field consultants and other university diagnostic labs to coordinate regional detection and provide inter-regional communication in the event of an outbreak. For more information on the NAHLN see http://www.aphis.usda.gov/animal_health/nahln/downloads/NAHLNBriefingCurrent.pdf

2. Other Agency Activities, also designed to do no harm

Integrated Pest Management: Section 15 of the Federal Noxious Weed Act of 1974, and the Executive Order 13112 on Invasive Species (signed in 1999) direct Federal agencies to use an integrated pest management (IPM) approach for the management of undesirable plants on Federal lands using all available tools, including: education; preventive measures; cultural, mechanical, physical, biological and chemical control; and general land management practices such as revegetation, manipulation of livestock or wildlife grazing, and improvement of livestock and wildlife habitat.

Integrated Pest Management provides a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks. The adoption and utilization of IPM is being encouraged through other legislative authorities within Federal departments. For

example, US Code (Title 7, Chapter 6, Subchapter II, Sec. 136r-1. Integrated Pest Management) states: "The Secretary of Agriculture, in cooperation with the Administrator, shall implement research, demonstration and education programs to support adoption of Integrated Pest Management." It further states "Federal agencies shall use Integrated Pest Management Techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies and other activities. IPM is also being encouraged across Federal agencies within the Department of the Interior.

Because of the complexity of economic, social, and environmental issues associated with invasive species management, and the biological and ecological attributes associated with each particular invasive species, programs that are based on a combination of technologies tend to be most successful and sustainable. As indicated in the National Invasive Species Council's (NISC) National Invasive Species Management Plan of 2001, the IPM approach considers the best available scientific information, updated target population monitoring data, and the environmental effects of control methods in selecting a range of complementary technologies and methods to implement to achieve a desired objective. Some of the factors to consider in selecting control methodologies include environmental compatibility, efficacy, cost-effectiveness, inter-compatibility of different types of control measures, practicality and safety. The adoption of an IPM approach for invasive species management will certainly help minimize harm to the environment, human health and wildlife.

3. Activities that are doing harm and future agency actions to change them so that they do not continue to do harm

Pesticide use that has negative impacts: Conventional pest management strategies using pesticides are still emphasized in the management of invasive species with potential negative side effects to humans, the environment and

wildlife. NIFA is helping to facilitate the adoption of an Integrated Pest Management Roadmap (IPM Roadmap) that will certainly help minimize harm to non-target species and the environment.

The goal of the IPM Road Map is to increase nationwide communication and efficiency through information exchanges among Federal and non-Federal IPM practitioners and service providers including land managers, growers, structural pest managers, and public and wildlife health officials. Development of the Road Map for the National Integrated Pest Management (IPM) Program began in February 2002, with continuous input from numerous IPM experts, practitioners, and stakeholders. The Road Map identifies strategic directions for IPM research, implementation, and measurement for pests in all major settings, throughout the nation. This includes pest management for areas including agricultural, structural, ornamental, turf, museums, public and wildlife health pests, and encompasses terrestrial and aquatic invasive species.

The goal of the National IPM Program is to increase the economic benefits of adopting IPM practices and to reduce potential risks to human health and the environment caused by the pests themselves or by the use of inappropriate pest management practices. The National IPM Roadmap has been recently updated and will be available on the USDA-OPMP (Office of Pest Management Policy) website October 1, 2013.

Pest Management Grant Programs: NIFA has several competitive grant programs designed to emphasize IPM, while reducing pesticide residues on food and in the environment. These include the Pest Management Alternatives Program, Integrated Organic Program, Methyl Bromide Transitions Program, Regional IPM Competitive Grants Program, and the IPM Centers. The emphasis of IPM and bio-based pest management in these NIFA competitive grant programs will certainly help minimize harmful side effects to non-target species and the

environment when these strategies are used in invasive species management.

IPM³ Training Consortium for Federal Employees: NIFA, in collaboration with Land Grant Universities and other Federal Agencies, has facilitated the development of an IPM distance education platform to provide IPM training to Federal workers involved in pest management issues and activities. Increasing the quality and consistency of IPM training among Federal agencies and their adoption of an IPM approach for invasive species management will certainly help minimize harm to the environment, to human health, and to wildlife. IPM³ currently offers the following training modules: IPM Core Concepts Module (English); IPM Core Concepts Module (Spanish); Pest Biology Module – Weeds; Pest Biology Module – Plant Diseases; Invasive Species Module; Fire Ant Module; Bed Bug Module; and IPM for Facility Managers and Supervisors; For more information on IPM³ please visit the following website: www.umn.edu/ipm3.

Pest Information Platform for Extension and Education (PIPE): PIPE is a reporting and tracking system, developed collaboratively with the USDA Risk Management Agency, to manage pest and disease information flow via the Web. The PIPE system provides real-time useful information to U.S. crop producers, and a “one stop shopping” center for timely, unbiased, national, and local pest information. PIPE fosters good farming practices by encouraging growers to: avoid unnecessary or ill-timed chemical applications; use the proper control tactics with the proper timing to manage crop loss risk; and document practices for crop insurance purposes. The PIPE system for soybean rust saved growers hundreds of millions of dollars in 2007 by providing real-time information that enabled the growers to avoid unnecessary chemical applications. Additional active ipmPIPE components include: soybean aphid, legume diseases, cucurbit downy mildew, pecan, and southern corn rust.

C. Economic Research Service (ERS)

1. Activities to do no harm

ERS is the main source of economic information and research from the U.S. Department of Agriculture. ERS research informs and enhances public and private decision-making on economic and policy issues related to agriculture, food, natural resources, and rural development.

Program of Research on the Economics of Invasive Species Management (PREISM): ERS initiated a new program of work in fiscal year 2003, the Program of Research on the Economics of Invasive Species Management (PREISM), to examine the economic issues related to managing invasive species in increasingly global agricultural markets. Through PREISM, ERS primarily funded extramural research through a competitive awards program that focuses on national decision making concerning invasive species of agricultural significance or affecting, or affected by, USDA programs. In addition to ERS-led analyses of invasive species issues, ERS has disbursed \$6.8 million through the competitive awards program to 45 recipients, including universities, other USDA agencies, and private non-profit institutions, for research on the economics of invasive species during FY 2003 to FY 2008. About \$1.1 million per year were allocated for extramural agreements in FY 2005 and FY 2006, while \$950,000 was allocated in FY 2007 and \$970,000 in FY 2008. No Funds have been allocated since FY 2008. ERS also organized annual workshops from 2003 to 2011 to provide a forum for dialogue on economic issues associated with agricultural invasive species.

Accomplishments of PREISM and outputs of PREISM-funded projects are reported in **Program of Research on the Economic of Invasive Species Management: Fiscal 2003-2011 Activities, which can be access at:**

<http://www.ers.usda.gov/publications/ap-administrative-publication/ap-056.aspx>

Following are some preliminary findings from PREISM-funded research projects:

- Prevention and management resources should be allocated to species and strategies with the highest return (in terms of damage reduction over time). Ideally, marginal benefits and costs should be equal across species and strategies.
- Decision-support tools that follow sound economic principles and reveal underlying scientific assumptions and value judgments provide a basis for expert and stakeholder involvement in decision-making and promote efficient allocations of funds.
- Optimal invasive species management strategies depend upon the stage of the invasion and associated rates of growth and spread. Eradication may be optimal for small invasions; reduction to a containment level for larger invasions. If eradication is feasible, the effort will reduce discounted damages more if it occurs early when populations are small. Delays result in more damages. If total cost increases rapidly as population increases, eradication when the population is small followed by prevention may be the best strategy.
- Under-funded eradication or management efforts can be cost-ineffective or wasteful, with little or no effect on invasive species growth and total damage. Higher initial expenditures can reduce long term damages and control costs, even if the species is not eradicated.
- For established invasive species infestations, per unit costs of removal can increase as populations decrease or become more isolated, making complete eradication difficult or cost-inefficient. In some cases, accommodation to low levels of invasion is economically preferable to the high cost of eradication. The higher is the cost of removal, the larger the population that will be accommodated.

- Higher invasive species infestation or population growth rates reduce benefit-cost ratios of control efforts, and at high enough rates, control might not be worthwhile. If population has surpassed that of maximum growth rate, the best strategy could be a pulse-like effort that drives populations below a critical population level and growth rate, followed by containment strategy.
- Probability of occurrence maps for invasive weeds based on GIS and other inventory or survey data and related population growth rates can improve weed management efficiency by reducing: 1) costs by targeting sites to monitor invasiveness, and/or 2) damage by initiating control of highly invasive populations before they spread.
- Coordination of regulations across U.S.-Canada, State, and provincial boundaries could: 1) more effectively reduce the cross-border spread of exotic horticultural plants that become invasive, and 2) reduce incentives for cross-border firm relocations to take advantage of more lenient regulations.
- Ecological and agronomic differences influence cross-State differences in noxious weed and weed-seed lists, but stakeholder lobbying also has significant effects.

2. Other Agency Activities, also designed to do no harm

ERS is not engaged in any activities that do harm.

3. Activities that are doing harm and future agency actions to change them so that they do not continue to do harm

None.

II. USDA Regulatory and Resource Management Agencies

A. Animal and Plant Health Inspection Service (APHIS)

1. Activities to do no harm

“Protecting American agriculture” is the basic charge of the U.S. Department of Agriculture’s (USDA) Animal and Plant Health Inspection Service (APHIS). APHIS provides leadership in ensuring the health and care of animals and plants and plays a vital role in ensuring the free flow of safe agricultural trade. The agency improves agricultural productivity and competitiveness and contributes to the national economy and the public health. APHIS has major regulatory authority to implement action programs to achieve these responsibilities.

For more detailed information and up to date highlights of program activity, please visit the APHIS Web Site (<http://www.aphis.usda.gov/>).

Invasive Species Prevention Programs: Specifically the APHIS mission, stated in its current strategic plan, is to protect the health and value of American agriculture and natural resources. To carry out this mission, APHIS works to achieve two interdependent goals:

- Safeguard the health of animals, plants, and ecosystems in the United States (U.S.)
- Facilitate safe agricultural trade

It does so through a system of interdependent objectives addressing exclusion (i.e., prevention), detection, emergency response, management, trade issue resolution, and capacity building. These areas correspond closely to elements of the National Invasive Species Management Plan.

APHIS tries to ensure that other entities in the private and public sectors, including other Federal agencies, "do no harm" by introducing or spreading invasive species. APHIS prevention programs – a comprehensive set of risk-based regulations and enforcement efforts -- are directed at animals, plants, and their products that may bring invasive species or be pathways for the introduction of invasive species. As such, the Agency addresses both unintentional and intentional

introductions of invasives. A description of some of the applicable regulations follows.

1. Regulation of certain animals and animal products:

APHIS regulates, as set forth in 9 CFR parts 91 through 99, the importation of animals and animal products to guard against the introduction of animal diseases into the U.S. in accordance with the Animal Health Protection Act.

2. Regulation of certain plants and plant products:

Regulations contained in 7 CFR part 319 prohibit or restrict the importation of plants, plant parts, and plant products into the U.S. in accordance with the Plant Protection Act. APHIS enforces the part 319 regulations and considers requests to amend the part 319 regulations to allow the importation of plants, plant parts, or plant products that are not currently allowed importation under the regulations. The requirements apply to many commodities, including nursery stock.

3. Listing of noxious weeds:

Under the authority of the Plant Protection Act, APHIS regulates, in 7 CFR parts 360 and 361, the importation and interstate movement of plants and plant products that may be noxious weeds, i.e., plants that can directly or indirectly injure or cause damage to crops, livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources, public health, or the environment.

USDA APHIS's Website Online Newsroom: this page (http://www.aphis.usda.gov/newsroom/hot_issues/index.shtml) provides links to several 'hot issues' such as efforts underway to eradicate various invasive pests, such as Asian longhorned beetle, as well as general guidance to avoid the introduction or spread of invasive species, such as guidance regarding the transport of firewood or products brought into the U.S. by travelers.

APHIS Plant Protection and Quarantine (PPQ)

PPQ safeguards agriculture and natural resources from the entry, establishment, and spread of animal and plant pests and noxious weeds into the U.S.; and supports trade and exports of U.S. agricultural products.

Risk Analysis Process: The risk analysis process examines the plant pests and diseases that are known to be associated with a commodity, identifies those pests that are likely to remain on the commodity upon importation into the U.S., and evaluates the mitigations that may be required to avoid, reduce, or eliminate the risk of pest introduction into the U.S. APHIS conducts risk analyses in accordance with International Standard for Phytosanitary Measures No. 11, “Pest Risk Analysis for Quarantine Pests,” and its supplements, set by the International Plant Protection Convention.

Plants and Plant Products Permits: Permits are required for the importation into the U.S. and transit through the U.S. of regulated plants and plant products for consumption or propagation. Plant and plant product permits include plants for planting such as nursery stock, small lots of seed, and post entry; plant products such as fruits and vegetable, timber, cotton and cut flowers; protected plants and plant products such as orchids, and threatened and endangered plant species; transit permits to ship regulated articles into, through and out of the U.S.; and departmental permits to import prohibited plant materials for research. The permitting system ensures that shippers and importers are aware of which products, and conditions, and allow for safe trade thus preventing the spread of harmful plant pests and disease. This process, along with scientific risk analysis, allows for an ample and diverse food supply as well as safe propagative material.

Crop Biosecurity and Emergency Response: PPQ, the Federal response agency for plant health emergencies, develops and delivers strategic science-based regulatory programs designed to protect U.S. crops and natural resources. PPQ strives to

deliver an effective systems approach to mitigate risks posed by select agents and regulated pests.

Accreditation, Certification, and Network Services: The Accreditation, Certification, and Network Services (ACNS) team manages the National Seed Health System; the U.S. Nursery Certification Program; the U.S. Greenhouse Certification Program; the State National Harmonization Program for seed potatoes; Special Foreign Inspection and Certification programs; Plants in Growing Media; Post entry Quarantine, Audit-based Certification Systems pertaining to section 10201(d)(1) of the Farm Bill; and the National Clean Plant Network pertaining to section 10202 of the Farm Bill.

The Center for Plant Health Science and Technology (CPHST) is the scientific support division for PPQ. CPHST is responsible for ensuring that PPQ has the information, tools and technology to make the most scientifically valid regulatory and policy decisions possible. In addition, CPHST ensures PPQ's operations have the most scientifically viable and practical tools for pest exclusion, detection, and management.

CPHST Plant Epidemiology and Risk Analysis Laboratory (PERAL): PERAL includes a diverse group of scientists and professionals comprising the primary office in Plant Protection and Quarantine (PPQ) for pest risk analysis. PERAL is responsible for providing essential scientific support to risk-based policy making across a broad range of phytosanitary issues. The staff uses scientific principles, procedures and evidence to analyze issues relevant to safeguarding plant health from the threats of harmful exotic pests of cultivated and natural plant systems. This includes most risk analyses required by PPQ for pests, Commodities, and pathways but it does not currently include risk analyses associated with plant pest permits, genetically modified organisms, or Federal Noxious Weeds.

PERAL serves a wide range of functions within PPQ. The overarching responsibility is to provide comprehensive, accurate information in support of the decision making process

ensuring that resulting actions are the most appropriate and “Do No Harm”. For more in-depth information regarding PERAL, please visit

http://www.aphis.usda.gov/plant_health/cphst/peral.shtml

A good example of one of these functions is the New Pest Advisory Group: The New Pest Advisory Group (NPAG) is located in the APHIS Center for Plant Health Science and Technology (CPHST), Plant Epidemiology and Risk Analysis Laboratory (PERAL). The overall goal of NPAG is to safeguard American agriculture and natural resources. The NPAG assesses new and imminent exotic plant pest introductions into the U.S. to recommend appropriate Plant Protection and Quarantine’s (PPQ) policy and actions to respond to the potential threat posed by such pests. In this case a pest is defined as: *Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products* [FAO, 1990; revised FAO. 1995; IPPC, 1997].

NPAG may address pests in many taxa including arthropods, plant pathogens, mollusks and weeds. It determines whether the pest is a present or an imminent threat, and if the pest meets the definition of a quarantine pest. If the pest meets the definition, NPAG may convene an ad hoc panel of Subject Matter Experts from PPQ, other Federal, state, and university sources with regulatory and scientific expertise for that particular exotic pest. Through literature searches, data sheet preparation and discussion with the panel, NPAG provides findings and recommendations via the NPAG Report to the APHIS Deputy Administrator and the APHIS Executive Team (represented by PPQ’s management) in response to the pest introduction.

Phytosanitary Issues Management: The Phytosanitary Issues Management (PIM) unit facilitates and negotiates, through the use of scientifically based processes, the safe export and import of plant-based agricultural commodities. By so doing, it prevents the introduction of invasive pest species.

APHIS Wildlife Services (WS) Activities

Nonnative, invasive species can be devastating to ecosystems where a lack of natural enemies and competition for resources can allow these species to thrive, wiping out other native wildlife in the process. APHIS WS' efforts target these introduced and invasive species. Invasive species of concern include brown tree snakes (BTS), Gambian rats, nutria, Coquí frogs, pigeons and starlings, house sparrows, feral swine and Burmese pythons.

Feral swine are an introduced species that pose a number of threats to humans, livestock and wildlife. Among these threats is the ability of feral swine to harbor a variety of federally regulated pathogens whose presence would result in severe economic loss to livestock industries. Estimates of economic losses from feral swine to agriculture and the environment average \$800 million annually. Feral swine have established populations in 38 states and are spreading rapidly. WS removed 28,498 swine in 26 states in FY 2012.

European starlings are an invasive species that invade livestock facilities, eating and defecating in feed bins. This fouling causes severe economic losses to the farmer and transmission of disease and loss of production in the animals. Estimates of economic losses due to starlings range from \$800,000 - \$4,137,119 annually in the U.S. WS removed 1,485,449 starlings from livestock facilities in 47 states in FY 2012.

Brown tree snakes have eliminated 10 of the 13 native bird, most lizard, and bat species on the island of Guam, are responsible for large economic losses from damaged electrical lines and resultant power outages, and pose a hazard to human safety from bites. APHIS continued to prevent the unintentional introduction of the BTS from Guam to other Pacific Islands, Hawaii, and the continental United States in FY 2012. The Agency intercepted 23,010 BTS on Guam or near ports of exit. APHIS WS National Wildlife Research Center scientists at the Fort Collins, Colorado headquarters, conducted an economic assessment of a hypothetical translocation of the BTS from the Territory of Guam to the Hawaiian Islands. The total annual

projected economic impact of the translocation of BTS to Hawaii was estimated to fall within the range of \$473 million to \$1.8 billion. These projections underscore the value of a BTS interdiction and control program on Guam.

The Gambian rat is a very large rodent native to northern Africa. Gambian rats can harm livestock species and habitats, damage agricultural crops, consume livestock feed, and are associated with a variety of pathogenic diseases that could be spread to humans, livestock, and wildlife. APHIS continues to work with the Florida Fish and Wildlife Conservation Commission, U.S. Fish and Wildlife Service, South Florida Water Management District, and the Florida Park Service to move toward the eradication of the Gambian rat from the Florida Keys. Removal methods have been successful and rat numbers are down significantly over previous years.

Nutria are large, semi-aquatic rodents native to South America, but are now established in 17 states and cause extensive damage to wetlands, agricultural crops, and structural foundations such as dykes and roads. The rodents may also threaten human health and safety and serve as a reservoir for tularemia and other diseases. APHIS is leading the first large-scale North American effort to eradicate a mainland population on the Delmarva Peninsula in Maryland where the rodents have devastated coastal Chesapeake Bay marshes. In cooperation with the Department of Interior's U.S. Fish and Wildlife Service, Maryland Department of Natural Resources, U.S. Geological Survey (USGS), Tudor Farms (a 6000-acre private wildlife management area) and 300 private landowners, APHIS has completed the initial nutria removal from more than 150,000 acres of coastal marsh in Maryland. The Agency is now expanding the search for established populations in major tributaries leading into the region. The Agency's wildlife specialists have developed and refined new removal techniques and have partnered with USGS to develop new detection and monitoring techniques including remote triggered cameras, call-back surveys, and other means of detecting low density populations. Through careful population monitoring, APHIS has successfully prevented the re-infestation of this

area, and marsh grasses and native muskrat populations are quickly recovering throughout the previously-impacted area.

In addition to the species highlighted, APHIS provides assistance to the general public upon request to resolve damage caused by invasive species. In FY 2013, APHIS provided direct control assistance to resolve damage caused by 14 of the 23 bird, mammal, and reptile species identified by the World Conservation Union (IUCN) as being among the top 100 invasive species in the world. These species included: Brown Tree Snake, giant toad, Coquí frog, red-vented bulbul, common myna, European starling, nutria, house mouse, roof rat, small Asian mongoose, feral swine, cats and goats.

APHIS Veterinary Services (VS) Activities

The National Animal Health Laboratory Network (NAHLN) is a state-federal cooperative effort including the APHIS National Veterinary Services Laboratories, which provide reference and confirmatory laboratory services including training, proficiency testing, and prototypes for diagnostic tests. The State/University laboratories in the NAHLN perform routine diagnostic tests for endemic animal disease as well as targeted surveillance and response testing for foreign animal diseases. The network will assist in early detection and rapid, scalable response to an exotic animal disease. For example, over 40 laboratories have been trained and proficiency tested to perform foot and mouth disease (FMD), avian influenza (AI), and exotic Newcastle surveillance diagnostics. A surveillance program for classical swine fever (a vesicular disease present in the Dominican Republic and Haiti) was established using NAHLN laboratories.

Cattle fever is a severe and often fatal disease of cattle transmitted by two species of tick. The ticks were eradicated from the continental U.S. in 1943, with the exception of a buffer zone between Texas and Mexico. An increase in movement of deer and stray livestock across the border has led to increased fever tick infestations in recent years despite a partial tick control border fence, livestock movement quarantines, and tick treatments for cattle and deer. APHIS is collaborating with ARS

and the Texas Animal Health Commission to explore alternative methods of tick control including baiting stations with acaricide-impregnated rollers and anti-tick vaccines (see ARS section above).

Swine influenza: APHIS continues to cooperate with Centers for Disease Control (CDC), state animal and public health officials in response to swine influenza spillovers into humans (and vice-versa). Epidemiology, virus sequencing and characterizations are performed to assess the risk of establishment and spread within the species.

Foot and Mouth Disease is the most communicable disease known, and is exotic to the U.S. APHIS activities have recently included vaccine and pen-side diagnostics studies, characterizing the pathogenesis and clinical signs in feral swine, and examining susceptibility of U.S. wild ruminant species. Validation of bulk-tank milk testing, virus-inactivating sample collection paper (allowing increased laboratory capacity) studies are ongoing.

FMD Vaccination policy: The policy regarding FMD vaccination vs. stamping out has shifted to make vaccination more likely in a large outbreak, in turn making eradication more likely in multiple scenarios. “Secure Egg Supply” and “Secure Milk Supply” plans for Highly Pathogenic AI and FMD, respectively, are being developed with commodity groups, states, and universities, making compliance more likely, in turn making eradication more likely.

Rift Valley Fever is an arthropod-borne zoonotic disease that infects humans and non-humans of Africa. U.S. mosquito species have been proven competent. APHIS activities have included diagnostic test validation, geospatial collaborations, and vaccine approval advice, steps and licensure.

Nipah virus is spread from fruit-eating bats to swine and can infect humans (from bats or swine). APHIS has collaborated with other agencies regarding vaccine approval advice.

Regulations on livestock testing: APHIS changed regulatory requirements for surveillance and pre-movement testing of livestock for brucellosis and tuberculosis after consultation with states, tribes, and the animal industry. In the U.S., these diseases of wildlife, livestock and humans currently exist only in limited wildlife foci. The changes should allow more efficient use of resources to allow continued control of the disease.

Disease spread modeling: APHIS is partnering with university and industry entities to increase the value of its disease spread modeling programs by adding livestock movement data. An exotic or emerging animal disease would likely move most quickly through current production-oriented animal movement.

Emergency management: A 'dashboard' allowing visualization of sampling, outbreaks, response measures, laboratory capacities, etc., has been developed by APHIS in collaboration with Department of Homeland Security (DHS) and one of their Centers of Excellence, which should allow syndromic surveillance (earlier detection) and more rapid and effective response to foreign and emerging diseases.

APHIS International Services

International Services (IS) supports APHIS' mission of protecting U.S. agriculture and natural resources in an international environment. An important activity is international capacity-building to prevent introduction of exotic pests and diseases.

Under 7 CFR § 371.8, IS is responsible for "monitoring and reporting the presence and movement of plant and animal diseases and pests in foreign countries." IS' field employees are the "eyes and ears" for the early detection and confirmation of emerging threats to U.S. agriculture. These employees are a critical component of APHIS' combined activities in detection and reporting of exotic threats, and all technical IS employees are expected to dedicate part of their time to these activities. These functions are part of IS' broader obligations to meet the APHIS mission in safeguarding U.S. agriculture, and surveillance activities are a routine function of IS personnel

stationed overseas. The information provided by IS is used by the other APHIS program units (Veterinary Services and PPQ) and may result in changes in regulatory status, entry requirements, etc.

IS performs various training programs abroad to enhance technical, administrative, and diplomatic skills and competencies. It contributes to international technical capacity building by supporting development of other countries' diagnostic and species identification resources. For example, IS distributed new Lucent keys to international partners (i.e. IICA, FAO, CARDI, CABI, OIRSA) and national plant protection organization (NPPO) counterparts via IS offices overseas. IS also forwarded the new identification materials/links to the University of Florida (UF) for dissemination to diagnosticians in the Caribbean Pest Diagnostic Network (CPDN) (which includes five countries where IS provided distance diagnostic equipment). The new keys were included in the resource materials provided to participants in the Regional Plant Quarantine Officers class funded by PPQ Greater Caribbean Safeguarding Initiative (GCSI) and given at the University of the West Indies (UWI) in Trinidad (in 2011 and 2012).

IS organized numerous capacity building trainings and workshops to train international NPPO inspectors and identifiers, to enable them to identify new pests entering their countries or to identify indigenous pests in phytosanitary export inspections (prior to export to the U.S.). Two examples include training in Asian Gypsy Moth Surveillance in Chile and a Giant African Snail Workshop in the southern half of South America.

2. Other Agency Activities, also designed to do no harm

Program protocols: APHIS follows protocols to ensure that its own activities and those of its state cooperators, carried out to exclude, detect, diagnose, control, and eradicate invasive species, do not contribute to the problem. These ongoing efforts include, in a general sense, agency personnel adherence to established biosafety procedures in programs to detect, diagnose, and conduct control operations for plant and

animal diseases and pests, both in laboratories and in the field; and assessment, in advance, of the probable impact of the use of biocontrol agents in programs to control invasive species.

3. Activities that are doing harm, and future agency actions to change them so that they do not continue to do harm

None. APHIS actions are consistent with the “DO NO HARM” objective of the Executive Order on Invasive Species.

B. Natural Resources Conservation Service (NRCS)

1. Activities to do no harm

The NRCS is well aware of the past, the present, and the potential future harm to the private lands in the U.S. from invasive species. The negative environmental and economic impacts of invasive species continue to be a large and growing problem for our Nation’s private landowners.

The primary invasive species focus for NRCS has been on terrestrial and aquatic invasive plants. Invasive plants have had large negative environmental impacts upon the intended uses of many privately owned lands and wetlands in the U.S. There have also been large negative economic impacts associated with the costs of invasive plant control. Invasive plants compete for soil nutrients and water in croplands and wild lands and often require the use of herbicides, biological control agents, or innovative control techniques. Invasive plants, often of poor forage quality, may out-compete native plants in grazing lands and wild lands rendering large acreages no longer useful for supporting livestock or wildlife. Invasive aquatic plants rapidly spread in water bodies and wetlands, removing the open water component necessary for many wildlife species. Of particular concern are the negative impacts from invasive plants, invasive invertebrates, and pathogens upon populations of native and introduced pollinators and their habitats as well as upon native threatened or endangered species and their habitats. The invasive species could have

devastating effects on desirable cropland and wild land plants and animals.

Publication and Revision of Agency Invasive Species Policy:

NRCS published its NRCS Invasive Species Policy in November 2004 and revised it in July 2010. The policy is available at

<http://policy.nrcs.usda.gov/ViewRollUp.aspx?hid=17018&sf=1>

The policy addresses the invasive species responsibilities at all levels (e.g., National headquarters, regional, state, and field offices) of the agency. It requires awareness by NRCS employees of the presence of invasive species and potential problems associated with them. It requires NRCS to work with partners and to use its human and financial resources for control, suppression, and/or eradication of invasive plants. The policy also requires that native plant species be used in vegetative conservation practices unless it can be demonstrated that no native species can achieve the desired conservation goals, or the desired native species is not available in the quantity required. Interim use of non-native, non-invasive species is allowed to provide the conservation function desired until native species can be established.

Assisting in the control and eradication of invasive plants:

NRCS provides U.S. private landowners with financial and technical assistance to control and/or eradicate invasive plants in an effort to maintain the desired vegetation (e.g., food crops and forage), to maintain the desired characteristics of the land (e.g., wetland open water), and to diminish invasive plants spreading to neighboring lands. NRCS frequently partners with local and regional weed control organizations for control of weeds on and off private lands. The agency encourages the use of integrated pest management (IPM) which may involve appropriate herbicides when necessary, the use of approved biological control organisms, and innovative cultural control methods for specific problems (e.g., black plastic). NRCS has placed increased emphasis upon the protection of wildland habitats for pollinators and other wildlife

Landowners that participate in some of the easement programs of NRCS (e.g., Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP)) are required to control invasive plants that might infest the easement lands. CRP and WRP participants may receive financial assistance to maintain these lands free of invasive plants. The Wildlife Habitat Incentive Program, Environmental Quality Incentives Program and the Conservation Stewardship Program also provide technical and financial assistance to help private landowners control invasive plants.

NRCS Conservation Practice Standards: NRCS has created a toolbox of 170 practice standards that provide guidance for applying conservation technology on the land and that set the minimum levels for acceptable application of the technology. These practice standards undergo periodic review for incorporation of new technology (generally every 5 years). Emphasis continues to be placed upon the identification and consideration of the potential invasive qualities of recommended vegetation, the use of native vegetation, and the protection and enhancement of pollinator habitat.

The NRCS Plant Materials Centers (PMCs): The 27 PMCs nationwide cultivate and provide seed stock of plants that are used for vegetative conservation practices within the geographical region served by each PMC. The PMCs encourage use of native plants, particularly source-identified plants, for restoration, reclamation, and conservation practice uses. The Plant Materials program uses an Environmental Evaluation to assess the potential invasiveness of plants being considered for release. If the potential for invasiveness is too great, other plants considered less potentially invasive for the particular environmental conditions are recommended.

The PMCs also used the Environmental Evaluation to review all prior NRCS conservation plant releases. For plant releases that were determined to be invasive or otherwise environmentally harmful, the PMCs discontinued their production. Once a PMC discontinues a plant release, NRCS plant materials specialists work with the appropriate states to

remove the invasive plant releases from NRCS state standards and recommendations so the plant is not recommended in the future.

Invasive Species and Compliance with the National Environmental Policy Act:

The NRCS National Invasive Species Specialist provided an overview of invasive species and the NRCS responsibilities through an agency-wide webinar as part of an Environmental Evaluation Series of webinars focused upon Special Environmental Concerns. Our agency's – and all Federal agencies' – responsibility to "Do No Harm" was addressed in the webinar. This overview is available at <http://www.forestrywebinars.net/webinars/environmental-evaluation-series-planning-for-prime-and-unique-farmland-and-invasive-species-special-environmental-concerns>.

2. Other Agency Activities, also designed to do no harm

PLANTS Database: The information about plant materials available through the PLANTS database (<http://plants.usda.gov>) is useful to conservation professionals and the public in determining beneficial plants that do well particularly for use in restoration activities following removal of invasive plants within a particular geographical location. It also has information on plants which should not be planted within a particular environment (e.g., Federal and state noxious weed lists). The database information provides assistance in assessing the potential invasiveness of specific plants. The PLANTS database has over 650 fact sheets on-line and provides services through over 70,000 user sessions per day. It encourages the use of native plants in conservation practices. Future capabilities of the PLANTS database will include invasive species lists (in addition to the existing noxious weed lists) for each state and information about the pollinators upon which specific plants are dependent, and recommended forage to encourage specific pollinators.

Addressing Herbicide-resistant weeds:

Due to the increasing occurrence of weeds that become resistant to the herbicides being used to control them, NRCS developed the Conservation Activity Plan (CAP Code 154) under the Environmental Quality Incentives Program, that provides requirements for a conservation activity plan for which financial assistance may be provided. The Integrated Pest Management (IPM) Herbicide Resistance Weed Conservation Plan documents decisions by producers who agree to implement a system of conservation practices and IPM techniques. This plan puts an emphasis on herbicide use orientation to suppress herbicide resistant weeds and, at same time, to reduce the potential for herbicide resistant weeds to again establish in the treated area of cropland by utilizing the four IPM strategies: Prevention, Avoidance, Monitoring and Suppression. This approach will be implemented with the augmentation of one or more of the following key essential conservation practices: Crop Rotations, Cover Crops, and Residue Tillage Management practices.

3. Activities that are doing/have done harm, and agency actions to change them so that they do not continue to do harm

Recommending invasive plants in conservation plans.

During the “Dust Bowl” days of our nation, immediate action was necessary to mitigate excessive wind and water erosion of our nation’s soils. Unfortunately, one of the mitigation tools that worked effectively was the use of non-native plant materials, some of which became invasive and presently are among the invasive plant materials we are trying to control. The use of the Environmental Evaluation by the PMCs before recommending specific plant materials for conservation is proving to be beneficial to avoid present and future problems of this kind. Also, encouraging the use of locally-acquired native plants whenever they can meet the conservation needs is enhancing awareness to NRCS state and field offices about invasive species problems and NRCS responsibilities.

The implementation of the NRCS Invasive Species Policy has made clear to all levels of the agency the responsibilities to

respond to invasive species problems, and to minimize or avoid future invasive species problems.

The state-specific Field Office Technical Guides provide technical guidance information for the specifics of each conservation practice standard within the specific State. Technical Guides may, in some cases, still recommend the use of plant materials that, in some situations, may have the potential to become invasive. NRCS has conducted and continues a review of all vegetative conservation practice standards to identify where this situation exists, and to work with the appropriate PMCs and State Plant Materials Specialists to recommend other appropriate and non-invasive plant material.

Use of herbicides or other methods that may have detrimental effects on native pollinators: Treatments recommended in some conservation practice standards for invasive plants may, in some cases, include the use of herbicides or other methods that may have detrimental effects directly or indirectly (e.g., habitat destruction) on native pollinators. NRCS continues to review and to revise all practice standards to identify such methods, and to recommend revisions that minimize or eliminate negative impacts to native pollinators. NRCS is developing a module within the PLANTS database that identifies specific plant-pollinator relationships and encourages the use of “pollinator friendly” plants in agricultural and wild land situations.

C. U.S. Forest Service (USFS)

1. Activities to do no harm

Policy Development – Forest Service Pesticide-Use
FS issued a revised internal Manual FSM 2150 on pesticide-use management.

USFS Invasive Species Management Strategy Revision –

As required by the Office of Inspector General's Audit on the USFS Invasive Species Program, the USFS revised and issued an internal National Strategic Framework for Invasive Species Management (2013), to supersede the 2004 National Invasive Species Strategy and Implementation Plan.

Policy Implementation - For invasive species management in National Forests and Grasslands: Issued in 2011, the new Forest Service Manual (FSM 2900) for invasive species management on the National Forest System was finalized in FY2012 and issued to the field. This new directive has been well received by public and private organizations, and has accelerated invasive species management activities across the 193 million acre National Forest System. This new policy has increased actions against aquatic and terrestrial invasive species at all levels. This policy is seen as a model for other federal land management agencies under the National Invasive Species Council.

Policy Development - NFS Invasive Species Management Handbook: The 2011 Forest Service Manual 2900 has laid the foundation for the accompanying Forest Service Handbook (FSH 2909.11 – NFS Invasive Species Management Handbook), currently under development. A national team is building draft content for the Handbook; which will articulate specific guidance, standards, criteria, rules, procedures, including, but not limited to: 1) Roles and Responsibilities for Invasive Species Management on the National Forest System, 2) Integrated Management Guidance, 3) Invasive Species Prevention and Control Procedures, 4) Invasive Species Early Detection and Rapid Response Criteria and Procedures, 5) Internal and External Coordination, 6) Record Keeping and Reporting, 7) Invasive Species Management Planning and Environmental Compliance/NEPA, 8) Contract and Permit Requirements and Related Oversight, 9) Inventory, Survey, Monitoring and Treatment Protocols, and 10) Invasive Species Management Program Training Requirements and Standards. The USFS is working closely with the National Invasive Species Council and the Invasive Species Advisory Committee on

certain aspects of this new Handbook. The development work with ISAC and NISC continued throughout FY2013.

Updates to USFS National Invasive Species Program Web Site:

USFS updated the portals, navigation, and content for the national website on invasive species. It provides user information on FS activities related to invasive species, policy, authorities, news and emerging issues. The site provides key contact information for invasive species program managers, access to cooperative projects and research, geographic information, species profiles, and techniques for preventing and controlling a wide variety of species. The website is <http://www.fs.fed.us/invasivespecies/>

USFS continued to expand activities against high risk invasive species throughout FY2013: in coordination with interagency groups such as ANSTF, ITAP, and FICMNEW, states, and others. For example, USFS personnel work closely with USFWS and other groups at the state, regional, and national levels to address the spread of White-nose syndrome disease in native bats. In addition, USFS personnel play a key role in preventing the spread of aquatic invasive species, particularly focusing on inspections, decontaminations, and interdictions at recreational use water-bodies and public use facilities located on National Forests and Grasslands. USFS also plays a key role in the implementation of the requirements of the QZAP plan, and USDA's priorities against aquatic invasive species, and maintains close coordination with other federal and state agencies.

Invasive Species Management Accomplishments:

In FY2013, the National Forest System increased its targets for invasive species treatments and expanded the integration of funding to accomplish these activities. Over 30 funding sources were available for invasive species management work, including increased focus on outcome accomplishments under the new Integrated Resource Restoration budget structure. It is anticipated that national output accomplishments across all invasive species taxa will likely exceed 350,000 acres in FY2013.

Research on invasive species:

Emerald Ash Borer(EAB) Natural Enemies Increased in U. S.:

USFS evaluated the establishment of one biological control agent, *Tetrastichus planipennisi*, imported and tested since 2007 for classical biological control of the invasive emerald ash borer (EAB). These natural enemies are tiny beneficial insects that eat EAB eggs and larvae. Between 2007-2010, *T. planipennisi* adults were released into each of six forest sites in southern Michigan. By the fall of 2012, 21.2% of EAB were parasitized in the parasitoid-release plots. These results demonstrate that *T. planipennisi* is established in southern Michigan and that its populations are increasing and expanding; therefore it will likely play a critical role in suppressing emerald ash borer populations in Michigan.

<http://www.treesearch.fs.fed.us/pubs/43739>

A field experiment examined how outer bark thickness of ash trees might affect parasitism by *T. planipennisi* and a native parasitoid, *Atanycolus* spp. USFS found that *T. planipennisi* was unable to parasitize EAB larvae in trees with outer bark thicker than 3.2 mm (>11.2-cm DBH) whereas *Atanycolus* spp. parasitized EAB larvae in ash trees with outer bark up to 8.8 mm thick (>57.4-cm DBH). These results suggest that establishment of, and control by *T. planipennisi* at release sites with only large diameter trees is less likely, and that *T. planipennisi* will be more effective in stands with younger trees (<12-cm DBH). Releasing *T. planipennisi* near the leading edge of EAB invasion may have little impact on EAB populations if many ash trees are too large. We recommend releasing *T. planipennisi* in stands dominated by small, early successional or regenerating ash trees. This may maximize the establishment and effectiveness of this species. This limitation of *T. planipennisi* for biological control of emerald ash borer suggests that other EAB parasitoids from its native range with longer ovipositors, such as *Spathius galinae*, should be sought and evaluated for possible use as EAB biocontrol agents in the US. The results of this study also suggest the importance of parasitoid guild in introductions for biological control in general,

and hint at possible broader implications relating to resource partitioning among native and introduced parasitoids.

Monitoring Data Helps Managers Prioritize Treatment of Threatened and Dead Ash Trees: With millions of ash trees dying all over the Northeast and Midwest, the dangers of falling branches and trunks are considerable. Forest Service scientists analyzed data on ash mortality, breakup, and tree-fall to prepare a comprehensive dataset on trees killed by emerald ash borer (EAB) in Ohio forests. Researchers were surprised to find that stands with high ash density actually die *slower* than those with lower ash density, which suggests that the strategy of thinning ash stands ahead of EAB may actually hasten the demise of the remaining trees. This dataset also paints an alarming picture of trees that rapidly become brittle, break, and fall. Park and land managers are using this information to justify removal of hazardous dead and dying ash trees in high-use parks and preserves. Survival analysis also showed that mortality was more rapid for trees shaded by other trees and for trees initially exhibiting dieback. In management scenarios where hazard tree removal must be spread over several years due to budget constraints, focusing initial tree removal on stressed trees is recommended.

To examine anticipated effects of EAB on tree species composition, USFS scientists modeled future spatial and temporal changes in forest composition over the next 50 years with and without ash mortality anticipated from EAB spread. We used U.S. Forest Service Forest Inventory and Analysis (FIA) data, the current extent of EAB in the U.S. and Canada, estimated spread rate and host mortality data, and a suite of human population, energy consumption, land use, and economic models to project the future condition of forests in the Midwest and Northeast United States. Results suggest that in most cases EAB will not have a substantial effect on ecosystem function of future forests measured by FIA because of the replacement of ash by other species. The transition from ash to other species may take many decades, but forests can eventually recover when a variety of associated species replace ash.

Breeding for Resistance to Emerald Ash Borer (EAB):

USFS scientists initiated a breeding program that employs two strategies to incorporate EAB resistance into North American ash species: hybrid and traditional breeding. In the hybrid breeding approach, we are looking for EAB resistance in Asian species of ash from EAB's region of origin. Asian ashes resistant to EAB will be crossed with native North American species to create hybrids. The hybrids subsequently will be tested, selected, and backcrossed to the native species, in a process repeated until only the resistance genes from the exotic species are carried into the native population while all of the traits of the native species are retained. For a more traditional breeding approach, USFS scientists are searching for rare native individuals with resistance or tolerance to EAB.

Advancing the Science about Sudden Oak Death (SOD):

USFS published Proceedings of the 5th Sudden Oak Death Science Symposium, including many papers documenting research funded by our Pacific Southwest Station. The volume provides 68 papers offering the latest information on pathogen monitoring methodology, spread, population dynamics, and fire ecology, as well as tests of control measures for nurseries, woodlands, and the urban environment.

Predicting Pest Establishments and Spread of invasive forest pests: USFS scientists compared historical records of invasive forest pest establishments, and how they spread. This information is used to develop a model of future pest risk that can be used to make prevention efforts more cost effective.

Assessing Resilience of Urban Forests: USFS scientists integrated two existing computer programs, the Pest Vulnerability Matrix and i-Tree Streets, into a decision-support tool for assessing municipal forest stability and recommending strategies to mitigate risk of loss. Grades were assigned to four aspects of a stable and resilient municipal forest: Species Dominance, Age Structure, Pest Threat and Potential Asset Loss. The data pool of 29 California municipal forest inventories contained information on 836,943 trees. Letter

grades were assigned to the four criteria and each city received customized recommendations for improving its grades.

Documented the abundance of nonnative plant species over 24 states: Introduced plant species have significant negative impacts in many ecosystems and are found in many forests around the world. Researchers found introduced plant species on two-thirds of forest inventory plots across 24 states in the northeast and Midwestern U.S. Vegetation data from 1,302 forest inventory plots revealed 305 introduced species, with multiflora rose being the most common species. Sixty-six percent of all forested plots had at least one introduced species. Because it compares the distribution of introduced species to native species in relation to forest fragmentation across ecological provinces and forest types, the study can help managers to target forest stands where management actions will be most effective. Identifying seemingly benign introduced species that are more prevalent than realized will help focus attention on newly emerging invasives.

Researchers find a way to control invasive leafy spurge using an insect: USFS researchers developed an innovative biological control method, which releases large numbers of a species of flea beetle—a natural predator of leafy spurge. Their efforts resulted in a 60 to 80 percent reduction in leafy spurge in one year. This technique has reaped substantial benefits for the “Hold the Line” program, a collaboration of county, state, and federal agencies as well as school districts and nonprofit organizations that has united to control leafy spurge.

Detecting the walnut twig beetle, a threat to walnut culture and timber production: In response to the threat posed by the walnut twig beetle (*Pityophthorus juglandis*) (WTB), which spreads thousand cankers disease in walnut trees, a FS scientist has developed a new highly effective lure. This synthetic form of a pheromone created by the male beetles will allow for much faster detection and mapping of this invasive insect, which has expanded its known distribution from 4 U.S. counties in 1960 to 100 counties by Sept. 2013.

An integrated conservation strategy for tanoak threatened by sudden oak death: A USFS scientist contributed to the first published biodiversity conservation strategy for tanoak (*Notholithocarpus densiflorus*) dominated ecosystems that are experiencing extensive decline due to the exotic pathogen, *Phytophthora ramorum* and the resulting disease, sudden oak death. The strategy questions the current management tactic of repeated clear cutting in an attempt to remove all hosts, since it has been shown this method does not succeed in eradicating the pathogen. Knowledge of pathogen behavior and stand growth characteristics, are incorporated into a model that demonstrates that tanoak can be maintained at low levels in infested stands, resulting in a recommended approach where steps are taken to improve stand or landscape resilience so tanoak survives despite the presence of the pathogen.

Global collaborations in biocontrol of weeds: Providing sustainable, environmentally safe solutions to problems of invasive plants is the goal of a small international community of researchers in biological control. USFS scientists and partners in the Pacific hosted the 13th International Symposium on Biological Control of Weeds in Hawaii. The newly published Proceedings highlight recent accomplishments and emerging issues in invasive plant management, and focus in particular on challenges faced by Pacific Island communities. Meeting for the first time in Hawaii, where the modern history of weed biocontrol began in 1902 with importation of natural enemies against lantana, provided a unique opportunity to take stock of a century of biocontrol. The organizers focused particularly on connecting Hawaii natural resource managers with international biocontrol specialists and raising awareness of Pacific island weeds as potential targets for research.

Best Management Practices Guide to Help Mitigate the Spread of Invasive Plants: USFS scientists developed best management practices (BMPs) that should significantly reduce the spread of invasive plants during timber harvesting operations. The BMPs are user friendly, relatively inexpensive, and research has shown that they work very well when used. The report explains how timber harvesting processes can

spread seeds, roots, and other parts of invasive plants; addresses the opportunity costs involved; and describes voluntary BMPs for mitigating invasive plant spread, thereby avoiding the ecosystem disruption that invasive plants can cause.

Biological control Agent for Chinese Privet Looks Promising: Biological control of Chinese privet, *Ligustrum sinense*, is the best long-term option for control of this widespread invasive plant in the southeastern U.S. A pre-release efficacy assessment was conducted by testing the effects of damage caused by a lace bug, *Leptoypha hospita*, on potted privet plants in the laboratory. Inoculating 15 pairs of lace bug adults on plants resulted in a significantly high defoliation rate, and reduced leaf biomass by more than 59% compared to 0 and 3 lace bug pairs. Leaf biomass of plants inoculated with 3 and 9 pairs of lace bug did not differ significantly from control plants.

Electronic Nose Technology Reviewed: Electronic-nose (e-nose) instruments, derived from numerous types of aroma-sensor technologies, have been developed for a diversity of applications in the broad fields of agriculture and forestry. Recent advances in e-nose technologies within the plant sciences, including improvements in gas-sensor designs, innovations in data analysis and pattern-recognition algorithms, and progress in material science and systems integration methods, have led to significant benefits to both industries. Electronic noses have been used in a variety of commercial agricultural-related industries, including the agricultural sectors of agronomy, biochemical processing, botany, cell culture, plant cultivar selections, environmental monitoring, horticulture, pesticide detection, plant physiology and pathology. Applications in forestry include uses in chemotaxonomy, log tracking, wood and paper processing, forest management, forest health protection, and waste management. These aroma-detection applications have improved plant-based product attributes, quality, uniformity, and consistency in ways that have increased the efficiency and effectiveness of production and manufacturing processes. This paper provides a comprehensive review and summary of a broad range of

electronic-nose technologies and applications, developed specifically for the agriculture and forestry industries over the past thirty years, which have offered solutions that have greatly improved worldwide agricultural and agroforestry production systems.

Meta-analysis of Seeding after Wildfires: Mitigation of ecological damage caused by rangeland wildfires has historically been an issue restricted to the western U.S. It has focused on conservation of ecosystem function through reducing soil erosion and spread of invasive plants. Effectiveness of mitigation treatments has been debated recently. USFS Scientists reviewed recent literature to conduct a meta-analysis of seeding after wildfires to determine if seeding may (1) protect ecosystems against soil erosion and (2) reduce invasion or abundance of undesirable nonnative plant species. Effectiveness of post fire seeding was examined in 8 erosion and 19 invasive species cases. Seeding has little effect on erosion during the first year after fire and is highly dependent upon initial establishment and coverage of species in successive years. Among all seeding cases, 28% reduced, 67% were neutral, and 5% increased invasive species abundance. Older seeding plots were more likely to show reductions in invasive plants than younger seeding plots. Seeding plots with high plant establishment were more likely to reduce invasive plants than those with low establishment.

Published Proceedings of the USDA Interagency Research Forum on Invasive Species: USFS published abstracts and papers of 75 oral and poster presentations on invasive species biology, molecular biology, ecology, impacts, and management presented at the annual Research Forum on Invasive Species.

Use of Internet: The USFS Research Program worked to improve use of the internet to disseminate research results. The national office website was redesigned to provide a “one-stop” umbrella for research programs in all the research stations. See: <http://www.fs.fed.us/research/invasive-species/>

2. Other Agency Activities, also designed to do no harm

Continue Implementation of Prevention Activities – Vehicle and Equipment Cleaning: During FY2013 the National Forest System (national forests and grasslands) (NFS) continued to implement vehicle washing activities/systems/protocols with public and private partners to prevent the accidental spread of invasive species by contaminated equipment and vehicles.

NFS Performance measures for invasives: The NFS maintained strong performance and accountability measures for all invasive species program activities, nationwide. These measures support the new NFS integrated resource restoration (IRR) budget structure. Field data was collected in corporate data management applications, and validated per the business rules and requirements. Program performance is outcome-driven and will emphasize the effectiveness of treatments. All NFS invasive species program performance outputs and outcomes were incorporated into the USFS Performance Accountability System for upward reporting in FY 2013.

Prevention language in FS contracts: In FY 2013, the NFS continued to use specific invasive species ‘prevention’ language in project contracts, agreements, and permits (such as timber sales, road management, facility construction, easements, grazing allotments, maintenance of right-of ways, facility operations, etc.) that specify requirements to minimize or prevent invasive species infestations and spread on national forests and grasslands.

Technology Development for biocontrol: USFS Forest Health Program (FHP-WO/FHTET) continued to support technology development for biocontrol of invasive plants.

3. Activities that are doing harm, and future agency actions to change them so that they do not continue to do harm

None.